THE NOVEMBER SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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with comments by the publishers

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THE SCIENTIFIC MONTHLY

NOVEMBER, 1927

MYSTERY MONUMENTS OF THE MARIANAS

By Lieutenant-Commander P. J. SEARLES

NAVY YARD, BOSTON, MASS.

THOUSANDS of miles from civilization, hidden in tangled jungle growths, seldom described and photographed, as have been the pyramids of the Mayas, the ruins of Angkor Wat or the monstrosities of Easter Island, for hundreds perhaps thousands of years, have lain concealed the mystery monuments of the Marianas. Surpassing Stonehenge in extent, with single stones larger than any in the pyramids of Egypt, these Lat'te or "Casas de los Antiguos," as they were known to the Spanish, are the relics of a race whose origin is lost in the dim mists of antiquity and whose history and characteristics had even been forgotten over four hundred years ago. What are they, why were they erected, and by whom? These are puzzles still to be solved.

The Marianas, or Ladrones, as they were formerly called, form a group of Pacific islands, roughly in Longitude 145 East and Latitude 12 to 18 North. Guam, the largest and most important, is an American naval station, while the others, Saipan, Rota, Tinian, Pagan, Agrigan, etc., were acquired by the Japanese following the World War. They are all typical tropical islands, with flora and fauna such as is widely found in the Pacific, and peopled by thousands of amiable, intelligent, handsome Chamorros, gently indolent under the southern sun. Thanks to American and Japanese influence, they have been provided with many modern comforts, electric lights, sanitary water supply, ice and cold storage, radio and cable service, medical attention, etc., without losing the quaintness and picturesqueness of the primitive.

Dotting the islands here and there are found those magnificent structures, the Lat'te, erected unknown centuries ago by a lost race whose name even is forgotten. Massive and imposing even when partially laid low by the hand of time working through earthquakes and typhoons, hid in the shadowy depths of the jungles, they convey an impression of high intelligence and skill on the part of their builders. Baffling to the scientist as well as to the layman, they represent an ancient epoch as mythical as Atlantis. What are they?

A Lat'te is composed primarily of upright monoliths called "halege," surmounted by hemispherical capitals called "tasa." The upright stones are usually placed in two parellel rows of from four to six stones in each row, the long axis of the Lat'te always being parallel with the line of the sea shore or a river bed. In Guam are found several different detailed forms. The uprights are sometimes slab-like, sometimes cut square; in fact, many shapes are extant. The capitals also vary in shape and size. Lat'te range from small rude structures con-

structed of natural boulders capped with coral heads, to massive stone columns, square in shape, fifteen or more feet in height and six feet in diameter, headed with enormous blocks of stone.

The Island of Tinian presents two of these largest of monuments carved by prehistoric man, part of the "House of Taga." The only standing survivors of ten original monoliths, these two shafts still rear their lofty heads on the southwestern side of the island, very near the beach. Three others are completely shattered as if by earthquake, two have lost their capitals, and three have fallen but still retain the "tasa" intact. They are all shaped like truncated pyramids, capped by hemispherical stones. The pillars are eighteen feet in circumference at the base and fifteen feet at the top. They are twelve feet high and support capitals five feet high and six feet in diameter. Each monolith weighs about thirty tons. The two parallel rows originally stood seven feet apart and form a ground plan about fifty-five feet long by eleven feet wide. They are cut from a rough metamorphosed coral known in the Marianas as "cascajo."

Don Felipe de la Corte de Calderon, Spanish governor of the Marianas from 1855 to 1866, in various manuscript reports to the Crown (not published), tells of the Lat'te.

It should also be noticed that not only Guam, but Rota, Tinian, and Saipan also possess ruins of houses of an architecture which tends to demonstrate the existence of a people gifted with certain ideas which showed them to be above the stage of the mere savage. All these ruins consist of pyramids finished at the top with semi-spherical, carved stones, the semi-sphere in some instances being biult of small stones cemented together.

In all the islands, at places formerly inhabited, are found certain monuments, which the natives call "latde" (sic), or "Houses of the Old People." They consist invariably of a

"THE HOUSE OF TAGA"
ISLAND OF TINIAN.

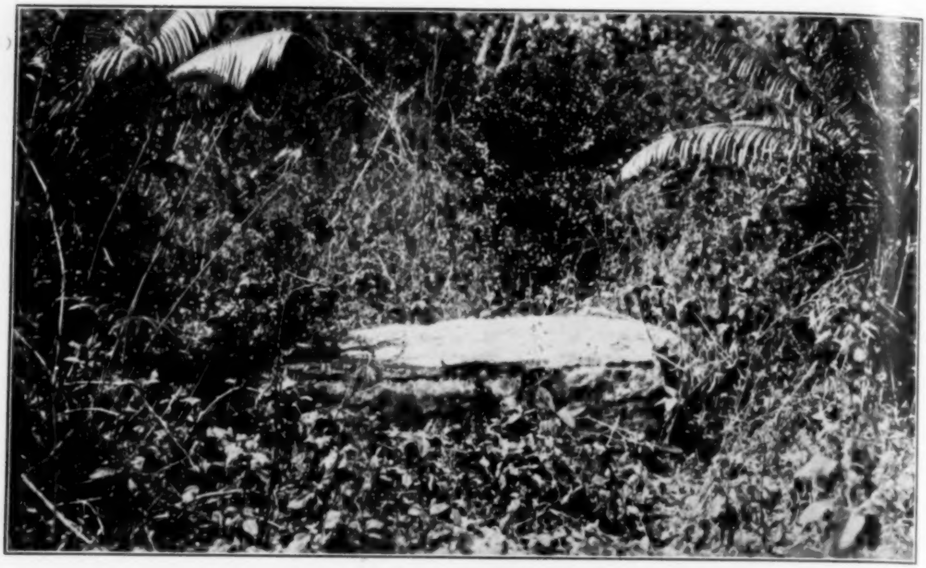
ONE OF THE SMALLER LAT'TE OF GUAM
SHOWING THE "HALEGE" AND THE "TASA."

double row of rough stone pyramids or truncated cones, supporting stone hemispheres, flat side up. These pyramids, similar in shape to the stone pillars called "Guarda Cantones," which are often placed along the edges of royal highways in Spain, stand in two rows, like the pillars of a house; and even though we have no exact data on the subject, this position together with their native name makes us believe that formerly they served as supports for stringers on which rested rafters that reached to the ground; but if this is correct, the house must have been very low. In early descriptions of the islands it is said that the natives buried their dead in the houses and even today the people have a superstitious fear of digging up or working the ground between these rows of stones. . . .

In Guam, Rota, and Saipan, the latde pillars consist of only two rough hewn stones, one cone shaped and the other a half sphere placed on top of it, both of them together not being higher than five feet from the ground; while in Tinian close to the Deputy Governor's house stands a group of these pillars, called "House of Taga"—a chieftain famous in local history —which is composed of twelve truncated pyramids four or five feet wide at the base and fifteen feet high, their squared tops measuring about two feet to a side. On them rest hemispheres from six to seven feet in diameter.

These pillars, crowned with their hemispherical caps and standing in two files, distant from each other about four varas from center to center, constitute a monument worthy of special attention, not so much for its size as because it resembles nothing to be seen elsewhere outside of the Marianas; moreover, it is not unique, but represents a type repeated over and over again in the other islands of the group. If we knew more about these latde we might determine the true origin of these natives of whom it may be confidently asserted that they are not the descendants of primitive savages. This is proved not only by the labor and skill required to dress the stones, but also by their unvarying

A LAT'TE COLUMN ON GUAM
ABOUT SIX FEET IN HEIGHT. THE WOMAN IS ONE OF THE FINE TYPE OF CHAMORRO.



THE JUNGLE REMAINS OF AN ANCIENT LAT'TE

pyramidal and hemispherical character. It seems strange that the history of the first missionaries makes no mention of them, since one would think such pillars could not fail to attract attention when discovered among the thatched huts of naked Indians.

Tradition has it that Taga buried his daughter on top of one of the pillars and covered her corpse with rice flour; when I visited this monument in 1855, wishing to confirm the story handed down by word of mouth, I had a ladder brought and climbed to the top of the pillar mentioned in the story and actually found a cavity full of earth and overgrown with shrubs whose trunks were two or three inches thick. After it had been cleaned out by my orders, I found a piece of a human lower jaw and two small bones, evidently finger phalanges. The grave cavity in the top of the hemisphere measured about five feet long by one and a half feet wide and deep, the corners being rounded.

Calderon is not altogether accurate, especially as regards the size of the Lat'te and about their not being mentioned by early missionaries. Gaspar and Grijalva described a boat house as being supported on strong stone pillars and sheltering four of the largest canoes. Richard Walter, chaplain of the "Centurian," one of the ships of Lord George Anson, who visited the Marianas in 1742, speaking of the Lat'te, says they are "in a style of grandeur passing anything which has been seen in the dwellings of the more eastern islands of the South Seas." In one of the narratives of Legazpi's expedition, it is said that some houses were supported on stone pillars and used as sleeping apartments, whereas cooking buildings, etc., were built on the ground. Legazpi mentions "arsenals" supported on stone posts. Reasons will be advanced later why it is not believed at present that the monuments were supports for houses or other buildings, but had an entirely different purpose.

Of the cause of their destruction we know nothing [says Arago, draftsman to Freycinet's expedition which landed at Tinian in 1819], for what credit can be given to a story like the following that the people are fond of relating: Toumoulou Taga was the principal chief of the island. He reigned peaceably and no one thought of disputing his authority. On a sudden one of his relations called T'joenanai raised the standard of revolt, and his first act of insubordination was to build a house similar to that of his chief. Two parties were formed; they fought; the house of the revolter was sacked: and from this quarrel which became general

arose a war that, while it depopulated the island, overturned its primitive buildings.

This tale is not now in circulation and certainly is apocryphal, for Arago's narrative in general is not entirely reliable. The chronicler continues:

The ruins best preserved are those to the west of the anchorage. The building there was composed of twelve pillars; of which seven only remain standing, the others lie at their feet; and what appears singular is, that the half sphere by which they were crowned has not been separated in their fall. Those found by the side of it (and the remains of which are more decayed, situated near the well, denominated the "well of the ancients") formed an edifice more than four hundred paces in length. The roots that still bind these old fragments, and the shrubs that crown their summits, present an interesting view.

Their proximity; their form; their material; the stone being composed of sand, consolidated by cement; that half-sphere surmounting a baseless pillar, erected on the arena; their position, and the distance that separated these different masses, without any lighter fragments occurring between them, induce me to think differently of the object of the building from the present inhabitants, who regard it as a royal residence. The space between the pillars is scarcely greater than the ground they occupy. What purpose could these massive tops answer? Who was the sovereign who inhabited the colonnade which certainly formed only a single edifice; the more I perambulate these ruins, and compare them with the genius of the present race of islanders, the more I am convinced that they are the remains of some public temple dedicated to religion.

To what God, to what spirit, to what genius was this temple consecrated? For it was certainly a temple, this vast monument more than a thousand feet in circumference.

Much has been made of the pillars on the island of Tinian, shaped like the rest in the form of a truncated pyramid and capped by hemispherical stones, wrote William E. Safford, but, in all probability, they are nothing more than the remains of large houses which served the same purposes as the "arsenals" described in the narratives of the Legazpi expedition.

Anson's chronicler says:

The equal height of the pillars and the shape of the capitals explain that they were designed for lodging a floor or platform and for preventing the ascent of rats and other noxious vermin. . . . Tinian swarmed with rats who were bold and familiar.

While the "House of Taga" is the most known of the Lat'te or "casas de los antiguos," there were rediscovered in 1924 on the island of Rota by Mr. Hans G. Hornbostel, of the Bishop Museum of Honolulu, remains of far greater structures. The principal edifice consists of twenty-five circular columns, four feet in diameter, and from four to sixteen feet high, forming a colonnade about eight hundred feet across.

The most impressive feature of the Lat'te is their enormous size and extent. In extent the one just mentioned is larger than Stonehenge, and the monoliths of fifty or more tons are heavier than the largest blocks of the Egyptian pyramids. But why were the Lat'te erected and by whom? As Arago says: "But what people erected above the earth these imposing masses, more than thirty feet high, well carved, regular without sculpture which fixes or which gives a clue, even, of the probable epoch of their mysterious foundation. What has become of the architects?"

Recent investigations indicate that the Lat'te are not remains of ancient dwellings, but that they are monumental religious structures, marking sites of ceremonies, cannibal feasts and burial. Many bones, pottery and other artifacts have been unearthed from the Lat'te sites. In Saipan, for example, a complete skeleton was found about two feet below the surface of the ground, lying on its back with its feet toward the sea. When the Japanese in Saipan excavated for buildings and for a railroad they unearthed relics of what must have been a vast ancient population. Bones, weapons, pottery, ornaments, have been found in Guam in such style and quantities as would preclude the Lat'te having been part of dwellings. Natives to-day frequently refuse to touch bones or articles taken from Lat'te, as they are

supposed to belong to "Tautau mona" or "people who came before," and consequently have evil powers.

In Guam the Lat'te sites can be considered as being divided, roughly, into three areas or groups. There is first the area of burial, which extends perhaps twenty feet from the Lat'te toward the sea or running water. Then there is an area devoted either to warriors slain in battle or possibly to prisoner victims of cannibal feasts, as shown by the skeletons having signs of considerable mutilation, such as broken skulls, missing legs or arms, spear heads in the skeleton. The third general area extends several hundred feet from the Lat'te toward the water, but not inland, and contains the remains of ornaments, pottery, weapons, stone implements, and is sometimes marked by a large stone mortar.

From the position of the skeletons it is thought that water bore a mystical or symbolic relation to life and death in the minds of the ancients. The feet almost always point toward the sea or running water and the head inland. Perhaps water was a symbol of birth and if, as seems possible, the ancients believed in a life after earth, the feet of the dead were placed toward water so that upon arising the newborn would be oriented toward the direction of new life. Some such relation there must have been or ceremonial burials would not have been conducted with such precision. Seldom is the position of the skeleton varied, and where this is the case, the skeletons are found carelessly interred outside a Lat'te as if to indicate lack of regard for the deceased, possibly because he or she were a criminal, cowardly enemy or some other such undesirable creature. Burials never took place on the landward side of Lat'te. Males were buried deeper than females, and children at a shallower depth.

The remains indicate that the builders and users of the monuments were cannibals. When illustrious dead were to be buried, ceremonial feasts were held at which, in addition to the regular foods, human flesh was consumed, the remains being deposited in the grave with the other articles, possibly to support and aid the dead in the journey to the next world. The victims of the cannibal feasts may have been unfortunate prisoners of war, but more probably were selected from the tribe itself, as the remains are more frequently of children than of adults. Perhaps in connection with the ceremonies the sun was worshipped, as stone dishes have been found with the design of the sun cut in.

How the Lat'te were built is unknown. Tools, chipped and polished from a basaltic rock, were the only implements the primitive people had, yet they formed blocks of fifty tons or more. The cultural level of the Egyptians was vastly superior to that of the ancient Polynesians, the Egyptian workmen knowing the use of bronze cutters set with diamonds and corundum, yet their pyramidal stones were not so large. Mr. Hornbostel has advanced the interesting and plausible theory that the stones were shaped by the alternate use of fire and water, the fire to heat and the water to crack, the process continuing until a huge monolith was fashioned from the rocky earth, later to be more carefully carved by the stone implements. By whatever means secured and erected, the Lat'te remain magnificent monuments to an ancient race, comparable, in size, skill and industry required, to the remains at Stonehenge, Easter Island or the Maya cities.

Who built the Lat'te and when? This is a mystery which may never be solved. It was almost certainly not the Chamorros found in the Marianas by the Spanish discoverers and settlers. When the Spanish first arrived, the Lat'te were already partly in ruins, and the natives disclaimed all knowledge of the builders.

except that they were "the people who came before." Cannibalism was unknown and forgotten by the sixteenth century, yet remains of cannibal feasts are found in the Lat'te. Perhaps they are relics of ancestors of the Chamorros, ancestors long dead and forgotten. Perhaps they were erected by a race antedating the Chamorros and which has disappeared in the mists of the past. Nothing corresponding to the Lat'te is found in Polynesia, but archeologists hope that in Micronesia and Melanesia further study may give a clue. Were the Lat'te only part of dwellings (though this hardly seems possible), were they temples to the sun or were they religious structures dedicated to ancestral worship? Have they a relation to any Asiatic monuments or to the astounding and unique figures of Easter Island? These questions still remain to be answered. But there in the Marianas the Lat'te stand or lie fallen in the tangled jungles, hidden by the dense growth of vegetation, far from the ways of man; monuments to a people of genius, lost in antiquity, who perhaps with weird rites sacrificed to the blazing tropical sun at a time when Rome ruled the world and Christ taught in Jerusalem.

THE ELEPHANT HEADS IN THE WALDECK MANUSCRIPTS

By J. ERIC THOMPSON

FIELD DIRECTOR OF THE BRITISH MUSEUM EXPEDITION IN BRITISH HONDURAS

THE casual discovery of a water-color and a drawing in an unpublished manuscript nearly a hundred years old may revolutionize our concepts of American history before the arrival of Columbus.

Some time ago the late Edward A. Ayer, well-known Chicago benefactor and trustee of Field Museum, Chicago, purchased the unpublished manuscripts, water-colors and drawings of the well-known nineteenth century explorer, Baron Waldeck. These documents he subsequently presented to the Newberry Library, of Chicago, where they now form part of the Edward E. Ayer collection.

The writer, while engaged on research work at the library, coming upon them, realized their importance as a possible source for the reconstruction of Maya history. Here were three perfectly good elephants' heads (Figs. 1, 2). If they were indeed trustworthy copies of the originals, how did it come about that the Mayas could reproduce so faithfully the features of the elephant? The true elephant, though once it roamed the plains of America, has been extinct in the New World for scores of centuries. It certainly ceased to exist long before man first crossed into America. The mammoth, too, was almost certainly extinct in America before the advent of man, yet if Baron Waldeck is to be trusted, the Mayas had a pretty shrewd idea of what an elephant's head looked like and could carve as good a representation of an elephant's head as any modern artist set to sculpture an elephant from memory or some crude drawing.

Baron Waldeck was one of the earliest explorers to make a detailed study of any group of Maya ruins. As early as 1832 he was at Palenque, measuring the ruins and copying the inscriptions and sculptured figures. He was engaged on this work for two years, and during such a long stay he had, needless to say, the opportunity to become thoroughly acquainted with every corner of the ruins.

Palenque, which in Spanish means "hitching post," is situated in the modern state of Chiapas in South Mexico. The climate is tropical and the whole country is covered with dense forest. The city itself is one of the finest ruins in the whole Maya area. Large temples set upon lofty pyramids abound and everywhere are found exquisite carved stones and stucco reliefs. The art of Palenque is unsurpassed by any other Maya city; indeed, it would be no idle boast to assert that Palenque art is superior to anything Egypt or Babylon ever produced. One of the finest buildings at Palenque is known as the "Palace," or Temple "C," and it was in a subterranean room beneath this building that Baron Waldeck discovered these memorable sculptures. On the wall was the elephant's head depicted full face (Fig. 2). The shaded part marks the part that Waldeck himself restored, as the original had in the course of centuries suffered considerable deterioration. The center of the drawing shows the elephant's head with mutilated trunk in air revealing the typical small diamond-shaped mouth of the elephant. Above and to each side are perched two gro-

tesque birds. The restoration made by Waldeck is based on similar birds found elsewhere at Palenque. Long necklaces, probably of jade, hang from their necks, terminating in pendant jade masks. The treatment of the feathers is very beautiful. Note how the tail feathers sweep round .beneath the geometric design.

The water-color (Fig. 1) depicts four stucco strips found by Waldeck amidst the rubbish on the floor of the same chamber. Waldeck surmises that in all probability they once formed part of the border of a stucco panel, possibly the panel showing the elephant full-face. The first strip shows two elephants' heads peeping out from amid the foliage of a vine. Here the representation is still more close to the original elephant. The tip of the trunk is neatly curled up and the tusks are very prominent. Note the large ears. Around each head is placed a band with a large jewel resting on the forehead. The leaves of the vines are very naturalistic. The second strip shows practically the same motif, but here, instead of elephants' heads, human heads are depicted. Possibly they represent Itzamna the sky god, who is usually shown with a large Roman nose.

The third strip shows two animals, which, though highly conventionalized, possibly represent tapirs. At all events the animal is obviously totally distinct from the elephant. In contrast to the huge cabbage-leaf ears of the elephant, this animal has sharp pointed ears. The treatment of the long nose is quite distinct, as too are the general features.

The fourth strip has as its motif what are apparently eggs.

If one could place full confidence in Waldeck as a trustworthy artist, there could be no reasonable doubt that the original did indeed represent elephants. Waldeck, however, who was in many ways more of an artist than an archeologist, was not strongly blessed with the gift of accuracy. A comparison of some of his drawings with photographs and the accurate drawings of A. P. Mandsley, reveal, on occasions, marked discrepancies. Waldeck, though accurate on general outlines, often displays a tendency to slur over minor details.

Furthermore, Waldeck held preconceived theories on the Asiatic origin of the Maya civilization, and any one looking for proofs to substantiate his theory seldom has any difficulty in finding them. Waldeck may, therefore, have "read into" the original figures elephants' heads which actually never existed. However, the boldness of the outline of the first strip would seem to point to the fact that he was copying from a clean and undeteriorated original. Unfortunately, the originals have in the course of the subsequent ninety odd years disappeared, and any hope of checking up on Waldeck's accuracy has thereby been dissipated.

For many years the belief has been generally held by the majority of American anthropologists that the civilization of America developed on American soil quite independently of outside influence. These scientists hold that such cultural traits as agriculture, pottery, the use of stone in architecture, metals, sun worship and other religious concepts were evolved here and were not borrowed from the Old World. On the other hand, there has recently grown up in Europe, especially in England, a school of "diffusionists."

The English diffusionists, whose chief exponents are Professor Elliot Smith, the famous anatomist, and Dr. W. J. Perry, lecturers in anthropology at London University, believe that a cultural trait is only invented once in the history of the world. These diffusionists hold that agriculture, pottery making, the use of stone in architecture, pyramidal structures, preservation of the dead, the use of metals, forms of social organiza-

FIG. 1. FOUR STUCCO STRIPS WITH ELEPHANTS' HEADS

tion and a score of other cultural traits were introduced into America by immigrants from across the Pacific. The home of these original travelers was Egypt, and, led by princes of the royal Egyptian blood, who claimed descent from the sun, they sallied forth from Egypt in search of gold, pearls and precious stones. Wherever they penetrated they found the aborigines living in a primitive Stone Age state. They settled among the aborigines, where as rulers they were worshipped as Children of the Sun and introduced their civilization and culture. Subsequently cut off from the original sources of their culture these outposts of civilization gradually degenerated, a process which was still working when the Spaniards reached the New World.

This theory has not found general acceptance in America, where the majority of anthropologists still hold to what might be described as the "Monroe Doctrine of Anthropology," or hands off America, home-grown American civilization for the Americans.

Elliot Smith some time ago attempted to show that certain Maya sculptures were intended to represent elephants, but his deductions were not generally accepted. Had he proved his point a serious blow would have been dealt to the Monroe doctrinaires, for had these sculptures been accepted as representations of elephants, the question at once arose, how did the Mayas ever become acquainted with the form of the elephant?

The diffusionists, of course, reply to this that the immigrant from across the Pacific introduced the worship of the elephant from Asia.

The Americanists, however, refused to recognize that these early sculptures represented elephant heads, but claimed instead that they represented macaws' or tapirs' heads.

Even should it be admitted that elephants' heads were portrayed on these

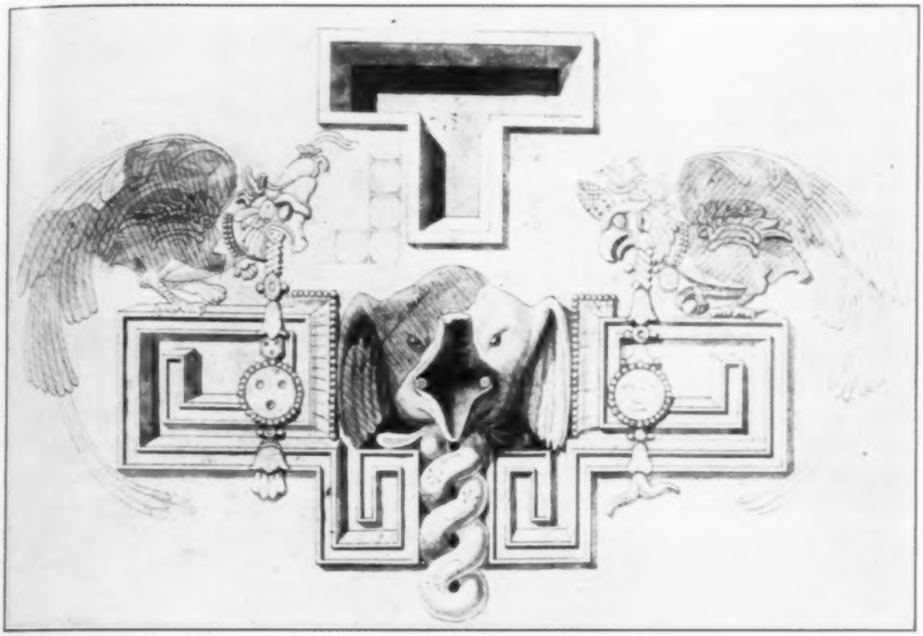


FIG. 2. ELEPHANT'S HEAD

Maya carvings, the diffusionist arguments would be as far from proved as ever. The attitude that American civilization was never affected to any appreciable extent by Asiatic influences would have to be abandoned, but there is a great difference between conceding this point and admitting that the whole of American civilization was of Asiatic origin.

Agriculture in the New World shows evidence of considerable antiquity. Many centuries must have been required to develop domesticated maize from its probable Mexican progenitor, the Mexican fodder grass. Furthermore, the agricultural products contributed by the New World are distinct from those originated in the Old World.

But the elephant motif appears in Maya art only about one thousand to two thousand years ago, the latter figure being in all probability too early. Thus agriculture existed in America long before the elephant motif, if indeed it is of Asiatic origin, was introduced.

In the Pueblo area of our southwest, thanks to the work of Earl H. Morris and Dr. A. V. Kidder, we are able to trace history down from the earliest primitive non-pottery-using basket-makers to modern times. Following on a period when no pottery was used, but only baskets, appears a period when the ancient Pueblo peoples made primitive pottery by daubing clay on their baskets. This is not definite proof of the invention of pottery in this area, but it is at least highly suggestive. Possibly pottery was invented quite accidentally in this area through a mud-covered basket having been close to a fire; the clay baked and the first pot had been made.

The diffusionists' belief that the arrival of the Children of the Sun synchronized with a sudden development of a high culture, followed by a period of gradual degeneration, can also be

shown to be ill-founded as far as the New World is concerned.

The earliest culture of which we have any sure knowledge is the so-called Archaic. The Archaic peoples covered the whole area from Mexico to the northern third of South America. Their civilization, though relatively advanced, shows many signs of crudity and lack of sophistication. The Archaics in Mexico and Central America wove quite good textiles, built adobe pyramids and made fairly good pottery bowls.

The Archaic culture was probably flourishing in the Valley of Mexico about 1,000 B. C. We are able roughly to date this culture, thanks to an accident, unlucky for the Archaics, but extremely lucky for modern archeologists. The Valley of Mexico was in the past a center of considerable volcanic activity. The lava flows from one eruption buried beneath its flow a considerable part of the valley. There are geological grounds for believing that this eruption occurred at the latest about 1,000 B. C. To-day the archeologists can dig below this lava crust and find the remains of archaic cemeteries and pyramids which were overwhelmed just as Pompeii was overwhelmed by the eruption of Vesuvius.

The Archaic civilization formed the basis on which the Maya and Toltec civilizations rested. Dr. Manuel Gamio during the past year laid bare many of the links that connect the Archaic culture with the Maya. He discovered new archeological sites in Guatemala that show the gradual evolution of the Archaic into the Maya. Almost step

—*Photograph by J. Eric Thompson*

FIG. 3. CONVENTIONALIZED "ELEPHANT TRUNKS"
ON ONE OF THE MOST BEAUTIFUL REMNANTS OF MAYA ARCHITECTURE AT CHICHEN-ITZA.

—*Photograph by J. Eric Thompson*

FIG. 4. TYPICAL MAYA OF TO-DAY

DESCENDANT OF THE BUILDERS OF THE OLD MAYA EMPIRE. ETHNOLOGISTS CLAIM TO SEE A RESEMBLANCE IN THIS PURE-BLOODED MAYA TO HINDUS; AN INTERESTING COMPARISON WITH HINDU NATIVE MIGHT BE MADE.

by step we can now watch the crude, primitive Archaic blossom forth into the classical beauty of the Old Empire Maya. So we see that instead of a sudden hothouse-like burst of culture followed by degeneration, the development has been slow and gradual but ever upward.

According to the diffusionist theory copper and bronze implements should be abundant in the early stages of American culture, but as time progressed and degeneration set in they should become scarcer and scarcer. Again the facts contradict this.

The early Archaics and the Maya of the Old Empire were apparently unacquainted with metal. It was not until late in New Empire times that metals came into use. Similarly in Peru, bronze and copper can be shown to be very rare in early times, but common just before the arrival of Pizarro and the Spaniards.

Dr. A. L. Kroeber, in the course of excavation in southern Peru for the Field Museum of Chicago, opened a very large number of Proto-Nazca graves. The Proto-Nazca is the earliest civilization known in South America. Out of the enormous collection of objects made from these cemeteries by Dr. Kroeber only some three or four objects are of

—*Photograph by J. Eric Thompson*

FIG. 5. DECORATIVE ELEMENTS ON A MAYA BUILDING AT CHICHEN-ITZA

WHICH SUPPORTERS OF THE ELEPHANT THEORY MAINTAIN ARE MASKS REPRESENTING DEGENERATE ELEPHANT HEADS WITH PROTRUDING TRUNKS. THE LARGE TEETH IN THE MOUTH OF THE SCULPTURED MASK IS REGARDED AS EVIDENCE OF THE "ELEPHANT ORIGINAL" IN CONTRADISTINCTION TO THE TAPIR OR MACAW THEORY.

metal, and these are all very small trinkets.

The Incas, however, who arose to power in Peru only some two hundred odd years before the Spanish conquest were abundantly supplied with bronze, copper, gold and silver. Inca collections, as well as collections from their contemporaneous neighbors, the Calchaqui of Northwestern Argentine, comprise enormous quantities of metal.

Architecture, too, shows evident traces of a gradual development. The Maya buildings of the comparatively late New Empire far surpass anything of which the Old Empire was capable.

Thus we see that in plastic art, the use of metals and architecture, the archeology of the New World upholds the tale of gradual development.

The position then seems to be this: The civilizations of the New World developed independently of outside assistance from the Old World beyond the fundamentals of life which the first invaders from Siberia brought with them. It will be generally agreed that the early immigrants brought with them on their long trip from Siberia across the Bering Straits into America via Alaska such fundamentals as the making of fire, the use of skins as clothing and the chipping of stone to make tools. Probably, too, the spear and the spear-thrower, the making of baskets and possibly even the bow and arrow should be added to this list.

Then, if the elephants are to be depended upon, long after civilization in the New World had gotten under way, influences that crossed the Pacific from Asia profoundly affected it.

Culturally, the effect would not have been great, but in the realm of religion the Asiatic influences may have been considerable.

In art, too, the effect may have been widely felt, for in every community except possibly the most sophisticated, art and religion are bound together by the most intimate ties.

As in so many thorny and problematical questions, each side will probably have to retreat from its uncompromising position sooner or later. The eventual solution of aboriginal American history will be found to lie between these two extremist viewpoints. What is required of archeologists to-day is less theorizing and more actual work. The Maya area is still to all intents and purposes a virgin field. The surface has as yet been barely scratched. Expeditions galore have traversed the Maya area, returning with reports of hardships and new sites discovered. It is not thus that history is reconstructed. With the exception of the work of the Carnegie Institution at Chichen Itza no attempt has ever been made to excavate systematically a Maya site. Systematic excavation is the only method of gathering the ends together. By painstaking but not spectacular methods is the past made to yield its secrets.

At present archeologists are too prone to fight with their tongues, forgetting that the weapon of the archeologist is his spade. Ten years' systematic excavation should go far to solve these problems on which to-day so much verbal energy is spent.

THE GOLD COAST

By CHARLES H. KNOWLES

DIRECTOR OF AGRICULTURE, GOLD COAST[1]

THE Gold Coast is one of the British colonies in west Africa. It is situated on the northern shore of the Gulf of Guinea and lies about five degrees north of the Equator. It occupies roughly a rectangular area covering over 91,000 square miles, and has a population of two and one fourth million natives and two thousand non-natives. The native population consists of many races and tribes speaking several different languages.

The climate is hot; in the forest it is humid, but it is much drier in the open country, comprising a narrow coastal belt in the eastern part and covering most of the country from about two hundred miles inland. For a tropical country the rainfall is not high. In the eastern coastal belt it is only about twenty inches a year; it reaches fifty to seventy-five inches in the forest and about forty-five inches in the open country. Most of the rain falls in the wet season, which extends from June to September. About the end of December a dry hot wind blows in from the Sahara. This is known as Harmattan and it is frequently laden with fine dust which is extremely trying. At the beginning and end of the rainy season tornadoes are

[1] One of the Smithsonian series of radio talks arranged by Mr. Austin H. Clark and given from Station WRC, Washington.

MR. KNOWLES ABOUT TO SET OUT ON AN EXPEDITION FOR PLANTING OIL PALMS

common, and sometimes do much damage by blowing down trees.

This part of the coast can not be called a health resort. In the old days malaria was so common that the country came to be known as "The White Man's Grave." However so much more is now known as to how to ward off this and other fevers and conditions in other ways have improved to such an extent that the name can no longer be applied without great injustice to the country.

The Gold Coast derives its rather pleasant-sounding name from the fact that gold is widely diffused there. Gold was the first reason for European trade, and it has regularly been exported since the discovery of this part of the coast in the fifteenth century. The wealth of the country proved very attractive to members of the various seafaring nations and considerable rivalry was thereby engendered. At first trading was done from the ships, but the European traders soon commenced to establish themselves on shore, the establishments taking the form of forts which were protected by cannon, both to ward off raids by the people of the country as well as to protect the interests of the builders from the unwelcome attentions of rival nations.

The history of the various forts would fill many volumes, some of them having changed hands many times, falling sometimes to the natives but more frequently passing from one European nation to another by conquest. The last to change hands in the Gold Coast was by purchase. Many of the forts are in a state of excellent preservation. Christiansborg Castle, near Accrá, the chief town, is the residence of the governor, while others are used as government offices.

The first administration of the country was by a company of merchants which was dissolved in 1821, and its possessions were then vested in the Crown, at first combined with other settlements on the coast, but constituted as a separate colony in 1874.

The early days of settlement were marked by various small disturbances, and after the people along the actual coast had become friendly and welcomed a measure of protection and settled administration, the more inland tribes, particularly the Ashantis, remained antagonistic until the beginning of the present century.

The whole country is now quite settled and the people can devote their whole energy to improving their well-being without the distractions incidental to protecting themselves against their neighbors or trying to redress fancied wrongs.

The Gold Coast is what is known in the British Empire as a Crown Colony. The government consists of a governor appointed by the Crown. He is advised by an executive council of officials, while a legislative council consisting of officials, representatives of the industries and of the people, makes the laws and controls finances, all subject to the general control of the Secretary of State for the Colonies. The people are governed through their chiefs. The various activities of government are carried out by a series of departments, the officers of which form the civil service.

Great headway has been made in sanitating the towns, while education and improved communications have had a material effect in improving the health of the inhabitants. Hospitals are established at all the principal government stations and medical offices are stationed at many other centers. At Accrá, the Gold Coast Hospital is one of the finest examples of a modern up-to-date hospital to be found in any tropical country. Attached to it is the Medical Research Institute and a training center for nurses and dispensers. It accommodates some hundreds of patients. Separate hospitals are established for Europeans.

and recently a maternity and child-welfare hospital has been established at Accrá under a woman doctor.

There is a keen demand for education. There are over 35,000 children in regular attendance at recognized schools. The latest development has been the establishment of the Prince of Wales College and School near Accrá at a cost of some three million dollars. It will provide instruction from the kindergarten upwards to university standard and will set the standard for the whole colony. The whole system at this institution rests on adapting education to native mentality, tradition and needs. It is a residential school and consists of substantial buildings containing quarters for students, classrooms, laboratories and the quarters for the staff. Recreation and playgrounds are provided and there is a large farm where agriculture can be taught. A staff of European and African teachers of the highest qualifications has been got together and part of the school is now working.

Up to the present the only way of reaching the steamers, which run direct from the coast to Europe, the United States and Canada, from the shore or *vice versa* has been by means of surf boats and lighters. Surf boats are sturdily built craft specially adapted to ride the surf which beats on the whole length of the coast line and which can be very heavy at times and at certain places. Indeed goods are sometimes lost, while occasionally passengers have had an exciting bath in the ocean. Each boat is propelled by about ten men—nearly always from the Liberian coast and known as Kroo boys—who adopt what seems to be an extremely uncomfortable and insecure perch on the gunwale and use a short paddle with a blade ending in three points based on the shape of the foot of a crocodile. These Kroo boys are exceedingly expert and apparently untiring boatmen.

A large harbor, however, is now nearing completion which will accommodate the largest steamers trading on the coast and providing full facilities for the rapid and safe handling of cargo. The cost will be about fifteen million dollars.

There are nearly five hundred miles of railway running from the ports of Accrá and Sekondi and meeting at Kumasi, the capital of Ashanti. One hundred miles of the railway is a branch running into the triangular area enclosed by the Accrá and Sekondi lines and the coast.

The railways are fed by about 4,700 miles of motorable roads, constituting the best and most developed system in British West Africa. Nearly three fourths of this mileage has been constructed in the last six years, and improvements of existing roads and extensions are being steadily carried out. Some of the roads are constructed by the chiefs and their people on their own initiative, showing their great desire to have the country developed.

People engaged in trade have been quick to see the advantages of motor transport and thousands of lorries or trucks are now on the roads. Indeed, as in many other countries, the railways are feeling the effects seriously of this competition.

As has been mentioned, gold attracted attention from the earliest times. Mining was entirely in the hands of the natives until the latter part of the nineteenth century. In 1879 a European company commenced working and from then there has been a rapid growth of the industry. Some of the mining ventures have been unfortunate, being heavily handicapped in the transport of heavy machinery through forest country entirely without roads. Much machinery is still to be seen abandoned in the forest without ever having reached its destination. Many mines, however, are working successfully and in 1925 the value of gold exported was over four million dol-

lars. Diamonds were found a few years ago and are now being mined. The export increased from $1,800 in 1920 to $900,000 in 1925. There are important manganese and bauxite deposits. The former were discovered during the war. Four thousand tons were exported in 1916, the quantity increasing to 340,000 tons in 1925. The mines fortunately are on the railway not far from Sekondi.

The people are chiefly agriculturists. They grow their own food and in former times used to extract rubber from certain vines and trees and prepare oil and kernels from the fruit of the oil palm for export purposes. At the present time, however, the only industry of any importance is the cultivation of cocoa.

The establishment of this industry had a certain amount of chance about it. One of the few islands near this part of the coast—the Portuguese island of São Thomé—has had cocoa cultivations for many years. Laborers were frequently obtained from the mainland. In 1871 one of these men, returning to his home in the Gold Coast, took with him a few cocoa pods, the seeds of which he planted in his garden. Trees soon developed and he gave away or otherwise distributed the pods, explaining what a lot of money was made out of them in São Thomé. It was soon seen that the trees thrived and a considerable demand for seed arose, so much so that as much as five dollars was paid for a single pod. Large quantities were then imported and planting became general.

The Department of Agriculture established demonstration plots where seed could be obtained, where information was available as to planting and cultivation of the trees, and where demonstrations as to methods of treating the plants and working up the crop were given. Officers of the department were sent through the country to teach farmers who could not visit the plots. The spread of the cultivation of cocoa, however, was so rapid that the efforts of the officers of the department could not keep pace and much ill-advised planting took place. However, in spite of this the soil and climate of most of the forest areas were so thoroughly suited to the requirements of the plant that the majority of the farms thrived even under a minimum amount of attention. The exports increased amazingly until now the Gold Coast is not only the largest cocoa producing country in the world, but it produces one half of the entire world's supply.

The first export was less than one hundred pounds in 1884. The exports rose to over 50,000 tons in 1913 and reached a record in 1926 with 235,000 tons. It will interest you to know that your country is our largest customer for cocoa. There are two very striking points in regard to the industry. The first is the rapid growth and the second is that it is entirely in the hands of peasant proprietors or small farmers, who plant as a rule a few acres each, while most of them are illiterate. It is here that the cocoa industry of the Gold Coast differs entirely from the industries of most tropical countries where planting is an organized business employing foreign capital and under the direction of highly trained agricultural experts; such, for example, as the sugar industry of Hawaii, the rubber industry of Ceylon and Malay and Java, the tea industry of Ceylon and the cocoa industry in many countries.

The people were quick to see that the crop offered much better prospects with far less labor than those they previously worked in such as palm oil making and rubber extraction, and they were ready to act on advice as to the methods which for a permanent crop differed so very much from those found satisfactory in the shifting cultivations of their annual crops.

The cocoa industry of the Gold Coast,

worth some fifty million dollars, shows what the individual farmers of a small country can do by their collective effort, entirely unaided by the use of what we should call capital, and it is an industry of which the country may justly be proud. The people have sometimes been credited with much success in avoiding the more strenuous forms of labor, but I think the cocoa industry alone proves that they can, and do, apply themselves to steady work which they know is to their advantage.

Being so dependent on one crop is equivalent to having all one's eggs in one basket. A watchful eye, however, is being kept on the basket. A law has recently been introduced requiring attention to be given to trees attacked by certain diseases. A special staff is employed for the purpose, while the general staff of the department, consisting of mycologists, entomologists, chemists and botanists as well as numerous trained tropical agriculturists, devote the major part of their time to matters connected with the industry.

Other industries which are being encouraged by the government are coconuts for copra, limes for lime juice, grape fruit, rice, cotton and sisal hemp.

The cultivation of Para rubber is successfully established and is carried on on European plantations and also by the natives. An effort is being made to revive the palm oil industry by the use of improved methods, while an effort is made to improve the quality of food crops.

At all towns facilities are provided for recreation and exercise by the establishment of cricket and football grounds, tennis courts, golf links and polo grounds.

Much sport is to be had. Several species of birds provide excellent sport and excellent food. Antelope is to be found in all parts from the small Dyka to the large harnessed antelope and in places larger species.

Elephants occur in several parts of the colony and the working up of ivory is a regular industry here and there. Leopard are found in the forest, and smaller members of the cat tribe are common. Lion and hyena are frequent in the more inland areas.

Pythons of large size exist and a variety of snakes—harmless and otherwise, while crocodiles of two species abound in the large rivers.

Those of us who are privileged to travel regularly through the country and who have a liking for natural history find much of interest, while an encounter with some members of the fauna can be anything but dull.

TROPICAL CLIMATOLOGY

By Dr. ALFRED C. REED

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CLIMATE represents the average state of the earth's atmosphere with its various components of air chemistry and physics. The chief elements which affect man are degree and variability of temperature, pressure, moisture, radiation (both solar and terrestrial), wind currents and magnetic and electrical states. Of equal importance for the race, though less for the individual, is agricultural climatology, as this concerns intimately the development of tropical food supplies. (See "Geography of the World's Agriculture," by Finch and Baker.)

We have to remember that the temperature of the earth's surface is compounded from direct solar insolation and retained terrestrial radiation. (See Brookes's "Evolution of Climates.") The latter is retained chiefly by virtue of atmospheric dust and moisture. Such dust is projected into the air largely by volcanic explosions, such, in recent times, as those of Krakatoa in 1883, La Soufrière in 1902 and Katmai in Alaska in 1912. Terrestrial and cosmic dust may prove of greater influence on climate than has been generally believed. E. S. King has advanced the idea that the planetary system and nearer stars are surrounded by extensive clouds of dust or some absorbing material which must affect radiation. The climatic results of dust and air moisture can be illustrated by a greenhouse, in which the glass roof permits free ingress of the solar radiation, but retains the terrestrial radiations which are of greater wave-length. It is evident that the angle of incidence has great weight in the penetrating power of solar energy either through glass or through the atmosphere, and the highest degree of insolation will occur where the rays are vertical, that is, for the earth, near the equator.

The chief controlling agencies in local climatic states are solar insolation, land and water aggregations, mountains, and currents in atmosphere and oceans. In the tropic zone insolation reaches its greatest height and constancy. The latter is of particular importance because monotony is one of the greatest foes of human life and achievement, whether it be in mental outlook, social contacts, political régimes or climate. The temperate zones, stretching between the tropics and the arctics, might better be called the seasonal zones because of their revivifying climatic contrasts.

A. Supan ("Grundzüge der physischen Erdkunde," 1896) assigns to the tropic belt that portion of the earth's surface lying between the isotherms of 68°, which roughly indicate the polar limits of palms and of trade winds. This zone widens over the great land areas of the Americas and of Africa. Continental climates, removed from the near influence of oceans, are apt to be more rigorous, with wider temperature range, greater dryness and dustiness. Land areas heat and cool more quickly than ocean areas, hence seasonal changes are greater and the seasons are not apt to be retarded as in oceanic climates. Coastal climate carries marine features a varying distance inland, depending to a great extent on adjacent altitudes and on the prevailing winds. Windward shores incline to a heavy rainfall. Lee shores in the trade belts may bring deserts to the sea, as on the western coasts of South America, South Africa and Australia.

A better understanding of tropical

climate will be achieved with some explanation, even if partly theoretical, of its historic development. It suffices to quote Brookes's "Evolution of Climate" and O. Peterson's theory of the tidal foundation of climatic epochs or cycles. Brookes draws the rule that there is a "basal" temperature for every latitude, to be found near the center of an ocean area in that latitude. This basal temperature is a function of the amount of land in that belt of latitude. In higher latitudes than 20°, greater land areas considerably lower the winter basal temperature and to a less degree raise the summer basal temperature for that belt.

Peterson's theory begins with the observation that the strength of the tides is greatest when sun and moon act in conjunction and are nearest the earth. These fluctuations of strength exhibit cycles, although the actual length of the periods is not constant. Greater range of tides causes greater diffusion of ocean waters by currents and therefore increased circulation between tropical and cold seas. Temperature variations in surface waters of the ocean result in more cyclonic activity and storminess at the times of greatest tidal range. The last maximum, about 1434 A. D., was accompanied by a general increase of storms and rainfall. This observation was confirmed by Huntington's study of sequoia rings in California. The next preceding maximum, about 350 B. C., was the culmination of the period of deposit of the great European peat bog formations, a period which included the time of the seventh century B. C., in which severe climate seems to have destroyed a preexisting north European civilization. Sagas and Germanic myths referred to this epoch as the "twilight of the gods," when frost and snow ruled the world for generations during the Early Iron Age and civilization in northwestern Europe retrograded. Brookes assumes that the present general distribution of land and sea has been constant during historic times and that general climatic changes have been chiefly due to tidal cycles.

The evidence of ruins shows population centers in ancient and prehistoric times where now desert wastes make settlement difficult or impossible. Such examples are seen in Arizona, Arabia, Yucatan, Central Asia and the Sahara. Ellsworth Huntington explains this change on the basis of his theory of shifting climatic belts. He believes that in periods of great storminess in the temperate belts, the temperate storm tracks shifted into sub-tropic belts, pushing toward the equator the high pressure climatic zone and causing cool dry winters, contrasting seasons and stimulating climate in regions which since have been returned to tropical conditions, as these storm tracks returned to the north. (See Huntington, "Civilization and Climate.")

Many geographers do not accept this theory, but it offers, none the less, a useful explanation and points an important proposition with reference to future occupation and utilization of tropical dry regions. It raises a serious question as to the type of colonization, character of industry and reasonable expectation of success, in civilized development of these regions. Progressive desiccation of central Asia resulted in the enormous migrations into China, India, the Near East and Russia, which have changed and controlled political and social conditions down to this day. Present extension of the Sahara, restriction of agricultural lands in Palestine and Syria, and indefinite availability of Mesopotamia for agriculture, are examples of the need of taking into account the history, evolution and tendencies of climatic change, in planning for human occupation of tropical arid areas.

Human achievement is not consummated by defying and conquering the forces or the laws of nature. Invariably it is won by understanding and utiliza-

tion of those laws. In human adaptations to climatic and geographic facts the same principle holds. Jean Brunhes ("Human Geography") well says, "It is better to content one's self with a half victory over natural agents rather than to expose one's self to defeats which are catastrophes." All too often the feats of civilization are not in accord with natural phenomena and are thereby doomed to destruction, even sometimes increasing the disastrous force of nature. Brunhes points out the enormous influence on the destinies of man of certain fundamental geographic facts, the "sovereign masters of men," which he summarizes as space, distance and difference of level. These "tyrannical factors of human geography" must be taken into account with the utmost consideration by those concerned with the future development of the tropics. Space now occupied and space available for occupation must be surveyed and studied. Distance means traffic and communications, with all the factors that facilitate and impede each, including native customs as well as natural phenomena. Difference of level brings into account the enormous potential forces of water-power, irrigation and climatic changes associated with altitude.

Man has reached his highest development in temperature zones, but nature is most prodigal in hot climates. Hence for his future, more and more, man must turn to the tropics for food and other resources. Medical science has its task in controlling and understanding tropical disease hazards. These hazards are inherent in the tropics and pertain to the natural phenomena of the tropics, to place and circumstance, and not to race.

The outstanding feature of tropical climate is its uniformity, lack of seasonal variation, and only local periodic weather changes, chiefly associated with the diurnal and annual variations in solar influence. The great exception to this rule is found in tornadoes, which will be discussed separately. In the tropic zone, mean temperatures are high, as stated above, lying between the isotherms of 68° and very largely included within the isotherms of 80° in tropical islands and to a considerable extent also on tropical seas. The warmest belt of latitude is 10° North. In most of this zone the mean annual range is not over 10°, on the edges approaching 25°, and on the oceans often not over 5°.

Tropical "seasons" are classified by rainfall and prevailing wind. The rains tend to follow the vertical sun, and therefore to show two maxima, as the sun is vertical both in April and in September. This is the equatorial type of rainfall. It is easily and frequently disturbed by local features of the geophysical relief, by monsoons and by the trade winds. Outside the equatorial type is found the "tropical" type of rainfall, where, as R. de C. Ward says, "the trade belts are encroached upon by the equatorial rains during the migration of these rains into each hemisphere," following the height of the sun. There are still two periods of vertical sun, but they come so near together that the maximal rainfall periods tend to merge, giving a wet season and a dry (or drier) season, that is, one maximum and one minimum.

The heaviest belt of rainfall is in the tropical doldrums, where barometric pressures are low, and where calms, squalls and light, baffling winds abound. Thunderstorms and heavy downpours tend to a diurnal periodicity, the sky is prevailingly overcast and cloudy, and the air is muggy and oppressive. The great tropical forests of central Africa and Amazonia are fostered by these conditions. Bright skies and tempered prevailing breezes are found, by contrast, in the tropical belts just outside this equatorial strip. Here the rotation of the earth sets up the great north- or southeasterly trade winds in the latitudes from 10° to 25°. Between 25° and 35° is found the belt of tropical calms, the "horse latitudes." Beyond these comes

the region of steady prevailing westerly winds. (See Fig. 68, p. 212, Huntington and Cushing, "Human Geography.")

It remains to call attention in the temperate zone belts of westerly winds to the characteristic occurrence of cyclonic storms, where a low pressure area five hundred to a thousand or more miles in diameter causes winds to blow toward their centers. These winds are deflected into a spiral or revolving direction. These storms are of immense health value by virtue of their rainfall, lowering of temperature and wide atmospheric disturbance. In them the air moves toward the central area of low pressure and then upward. In their accompanying anti-cyclones an area of high pressure causes the air to move downward so that it becomes warmer, holds moisture better and therefore is not accompanied by clouds and rainfall. These also cause constant changes of weather, which are beneficial to health. Intense cyclonic storms in the trade wind zone are often of small area and very destructive in their effects. These are called hurricanes. Since the earth's axis is inclined to the plane of its orbit, seasons are produced as the vertical rays of the sun, followed by all the climatic belts, migrate between the latitudes of 23° north and south. (See Huntington and Cushing, "Human Geography," Fig. 70, p. 219.)

In general, tropical and subtropical seasons are classified by and consist of changes in rainfall. Temperate seasons depend on temperature changes, with abundant precipitation in all seasons. Huntington and Cushing point out that for this reason inhabitants of these regions are more widely distributed and resourceful than elsewhere, as, for instance, in the arid regions of the tropical high pressure belts.

Altitude

Elevation of land plays an important rôle in tropical climatology. Variations of winds, temperatures, storms and barometric pressures are introduced by increased altitudes, resulting in a more stimulating and healthful climate in plateau and mountain regions. In general, tropical mountain climates follow the rule of lower temperatures; more variability of temperature and abundant cloudiness and rainfall. The effect of increased insolation is relatively greater than in higher altitudes because of the vertical sun. Often these uplands are closely adjacent to unhealthy lowlands and their utilization for holidays or even for regular residence adds greatly to the health and comfort of those whose occupation is in the lowlands.

Each 330 feet of altitude in summer and each 400 feet in winter connotes a 1° decrease in temperature. Hence large high land areas favor glaciation, as on the Ruwenzori of central Africa and on the Andes. In addition to its effect in lowering temperature, altitude also decreases barometric pressure and absolute humidity. On the other hand, insolation and radiation rapidly increase. The lack of moisture and dust in the atmosphere are important aids in this. In cold seasons and at night the cold air from aloft flows down on valleys and plains and is replaced by the warmer air from below. In hot seasons and in the daytime there is an ascending current. In determining the health effects of altitude we have to consider the degree of insolation (that is, the latitude and the degree of elevation), the amount of cloudiness, local topography, winds and resulting local humidity, as well as variability of climate. The effects of drying (due to dry air and winds), lowered pressure and increased sunlight are very definite. Excessive drying is even more harmful than excessive humidity, except under conditions of very high temperature. Sun-glare and extreme drying qualities are important elements in making highlands less available for human habitation.

As locations for permanent residence

it is not possible, however, to assume that tropical highlands are completely healthy or to compare them equally with elevated regions in temperate latitudes. In other words, we can not say that altitude completely neutralizes and compensates for the chief characteristics of tropical climate; *i.e.*, humidity, low barometric pressure and high temperature. There is another group of considerations of the utmost importance. Habitable altitudes in the tropics share in the great tropical characteristic of excessive climatic monotony. This is not so pronounced as in the lowlands, but it remains a factor of hygienic importance. The danger of breakdown under hard work is very imminent. The nervous system suffers and, for whites, acclimation without deterioration is most difficult. Few definite observations and figures are to be had and the matter is worthy of serious investigation. Tendency toward nervous and mental breakdown is to be expected from long residence in tropical highlands, or else a progressive inertia and mental deterioration. Geographically these regions impose other handicaps, such as difficulty of communications and human circulation, isolation, and, as always in the tropics, close contact with native races whose influence is definite and debilitating. The general features of tropical psychology apply here as in the lowlands. It is safe to assume, therefore, that tropical altitudes afford valuable sites for recreation and vacation for tropical workers in the lowlands; that, whenever it is possible, residence in the highlands is preferable to residence in the lowlands; but that permanent residence in tropical highlands offers serious dangers and is a subject needing much greater study. The abundance of causes and of vectors of disease in low areas tends to drive man to higher altitudes for his chief settlements, as we see in the history of Central and South America. Mountain sickness and thin atmosphere tend to keep him from going to excessive altitudes. The great ancient civilizations of the tropical Americas were at moderate altitudes and there to-day is where the denser population is found.

Variability

No element of climatic influence on man takes precedence over variability. Conversely, monotonous climate is among the chief enemies of man in the tropics. Physical and psychical energy decline in the absence of climatic stimulation. Mental, physical and moral health decrease, lacking the tonic invigoration of climatic change. The great virtue of temperate zones lies not in less heat, less humidity and less insolation, but in the advantage of seasonal and diurnal changes of weather, including the effects of cyclonic storms. The evident favoring influence on civilization and human energy is an index of this relationship. Perhaps climatic monotony is the white man's greatest tropical handicap.

For practical uses we can omit more than reference to climatic cycles which have been noted previously. Lack or insufficiency of seasonal change in the tropics is inherent in the low latitudes. Cyclonic storms are represented almost wholly by hurricanes which are local and infrequent. The common thunderstorms do not materially alter temperatures.

Variability in climate has a definite and considerable effect on the development of resistance to disease. Tropical monotony therefore paves the way for disease. At the same time it furnishes conditions of constant high temperature and moisture advantageous for the propagation, vigor and survival of pathogenic bacteria and other microorganisms, as well as for the optimum growth of vectors.

It is doubtless true that climate has not received due consideration as an important factor in civilization and individual character. The element of varia-

bility takes high rank in climatic influences which to a surprising extent control human energy, civilized advancement and individual achievement.

Light

Tropical light is part of the more general subject of tropical insolation. It affects man by two methods, (1) the influence on general climatic conditions, constituting what is called solar climate, and (2) direct effect of radiation on man himself.

1. The general effects on tropical climate have been noted, with the peculiar double maxima of insolation and rainfall which are found between the latitudes of 12° north and south. At the latitude of 15° these have merged. Insolation is controlled especially by the obliquity of incidence of the sun's rays, by the thickness or density of the atmosphere, and by additional substances in the atmosphere such as dust and moisture. Of the sun's energy impinging on the atmosphere in the tropic zone, two fifths to one half does not reach the earth's surface.

2. The question of the nature and degree of the influence of insolation on man is far from clear. The chief difficulties in arriving at a solution of the problem are (1) the length of observation necessary, requiring many years or even several generations; (2) the close association of other complicating factors of tropical life and climate; (3) the need of subjects free from disease and with normal blood and nervous systems; (4) unknown reactions due to race, degree of pigmentation and psychologic status, and (5) difficulty of securing adequate controls. C. W. Woodruff ("Effect of Tropical Light on White Men") lays the backwardness of mankind in the tropics to excessive insolation, which first stimulates and then disorders the human organism. The actinic, or ultra-violet, section of the spectrum of sunlight is held at fault by him. Woodruff's book should be read, but with a careful regard for the five criteria just noted. There is much experimental and clinical evidence that the actinic element of sunlight does have an initial stimulating effect on tissues exposed to it, an effect distinctly different from the red or heat rays. Skin directly exposed to the sun reacts at once to the heat rays with a mild erythema. The same effect takes place through ordinary glass. But direct exposure is followed in three or more hours by "sunburn," a result not obtained under the protection of glass, which absorbs the actinic rays. It has been shown that the reaction of the skin to chronic insolation includes pigmentation, which thus becomes a protective mechanism. Chalmers and Castellani ("Manual of Tropical Medicine") refer to a case of leucoderma in a tropical native who suffered severely, when exposed to the sun, from nausea, vertigo, weakness and local pain.

The effect of light on the constituents of the blood has entered a new chapter with the researches of A. F. Hess, H. Steenbock, Kugelmass and MacQuarrie (*Science*, September 19, 1924) and others on the activation of blood lipoids by radiation with sunlight. While these studies have been largely concerned with the cure and prevention of rickets, they open a suggestive field in general nutrition and general physiology. Hess (*Jour. Am. Med. Assoc.*, April 4, 1925) refers to the common knowledge among botanists of the influence of the actinic rays of the sun on plant physiology, to their deleterious effect on bacteria and to Finsen's observations on their beneficial action on certain skin eruptions, as in lupus. Rollier has been largely responsible for the use of heliotherapy (utilizing the ultra-violet rays) in the treatment of tuberculosis of bones and glands. Finally it was demonstrable that rickets was a direct result of insufficient ultra-violet radiation, resulting in deficiency and disturbance of calcium

and phosphorus metabolism. Hess summarizes our knowledge of their physiologic effects as follows. They have remarkably little power of penetration. They are easily absorbed by dust, smoke, fog and moisture in the atmosphere. The average or total annual or seasonal amount of sunlight does not determine the amount of ultra-violet rays reaching the earth, but rather the vertical incidence of sunlight when the actinic rays are not so largely absorbed in the atmosphere. Thus while temperate zones may have a greater number of annual hours or days of sunlight than do the tropics, especially in winter there is a deficiency in ultra-violet rays with a definite increase in rickets.

It is possible to activitate certain foods by ultra-violet radiation so that they develop the same anti-rachitic properties as those of cod-liver oil, as, for instance, dried milk, certain cereals, meat, egg yolk, refined flour, certain leafy vegetables and vegetable oils. This anti-rachitic element resulting from irradiation has been called Vitamin D, but there is much uncertainty as to its being a separate substance. It is associated with lipoids of the nature of sterols, as cholesterin. Hess has suggested that cholesterol may be the chief substance capable of activation by radiation. At least we know that radiation of the skin affects the whole body. Cholesterol is especially abundant in the outer skin, is carried in the blood stream, and is found in the tissue cells. Hume, Lucas and Smith (*Biochem. Jour.*, xxi, 362, 1927) have shown that Vitamin D can be secured in sufficient quantity by the body through the medium of inunctions of irradiated sterols.

It is equally true that the invisible actinic rays have a destructive action, when their intensity is relatively excessive for the substance radiated. Exposure of eggs and embryos of lower animals leads to development of monsters, freaks, one-eyed fish and numerous abnormalities of structure. Marie Hinrichs believes that death and distortion are produced by excessive exposure to these rays because they tend to attack the strongest points of living matter, where life processes are most active, where vitality is chiefly centered. There is need of experimental data along this line as to the influence of tropical light on developing and growing human child life and on perversion of physiologic processes in adult life. Radiation of milch cows has been shown to increase the Vitamin D content of the butter fat, but C. E. Bills does not find the same result when fish are exposed to ultra-violet radiation. He suggests that some unknown biologic mechanism comes into play in the fish liver to activate the oil.

In considering the effects of tropical light, we are brought face to face with a difficult, poorly understood and highly important subject, the photodynamic action of radiation. Bovie (*Oxford Med.*, iii, 368) says that "there is for most living things an optimum intensity of illumination which is a necessary condition for the maintenance of a normal reaction between the organism and its environment." This optimum varies for different plants and animals. Muscle-tone of animals is produced by light and in insects, at least, conditions their phototropic reactions. The chemistry of the retina illustrates the highly developed nature of this "chemistry of light," but its mechanism is poorly understood. "The protoplasm at the tip of an ordinary oat seedling is even more sensitive to light than is the human eye" (Bovie). Probably the cell nucleus is more sensitive to radiation than cell cytoplasm. Growing cells seem more sensitive than when mature or at rest. Here is more than a suggestion of explanation of the pernicious effect of tropical climate on infants and children, perhaps even on intrauterine life.

It is true in general that only absorbed radiations modify protoplasm. Altera-

tion in chemistry as a result of radiation, therefore, means first absorption of rays, and secondly, presence in the protoplasm of photosensitive substances. After a latent period, with simple lapse of time, or on the addition of a new chemical or physical impetus or stimulation, alteration will occur. This is demonstrable in the case of simple tissues and simple organisms. Bovie exposed egg albumen to ultra-violet light at 0° C. with no visible change in its constitution. At any time up to a month and more later, warming up to room temperature caused immediate coagulation. It is probably even more true when we attempt to trace the results of insolation in a tropical population and especially in persons not acclimated in the tropics. The slowness of the alterations produced, their consummation by secondary stimuli of many, and often unknown, natures, together with the numerous other factors which tend to distort the picture, altogether account for the extreme difficulty of studying the real effects of insolation.

Certain known diseases, in which structure and function are grossly disturbed, have been related to solar radiation. Among such are, for instance, Xeroderma pigmentosum of Kaposi, sunburn pigmentation, the rash of pellagra, the light-engendered rash that sometimes follows the eating of buckwheat and other substances, migrainal sneezing on going into bright sunlight, the influence of sunlight and red light on some febrile eruptions, possibly sunstroke and tropical neurasthenia. Pearce and Brown (*Journ. Exper. Med.*, April 1, 1927) have reported a suggestive study of malignant disease in animals, indicating a correlation between light and the manifestations of malignancy. For it has been shown that sufficient ultraviolet radiation is essential for life and for health, but excessive or deficient radiation leads toward disease and death.

It remains to mention another type of light exposure which may be of special importance in the tropics. D. S. Macht has shown some remarkable effects produced on chemical and physiologic processes by polarized light. In polarized light the vibrations all lie in one plane. Such light is indistinguishable to the eye from ordinary light. This quality is found especially in reflected light, as from water surfaces, glass, tin and moonlight. It promotes the conversion of starch into sugar, stimulates growth of bacteria, seeds and sprouts and yeasts, and perverts or changes the activity of certain drugs, as digitalis, quinine and cocaine. It causes greater susceptibility in sick or poisoned rats. If followed by ultra-violet radiation, it caused convulsions and death. These results are very suggestive and open a huge field of tropical research which thus far has not even been touched.

Winds of Special Types

1. *Trade Winds.* These winds blow uniformly and steadily from the subtropical high pressure belts, 25°–35° latitude, toward the low pressure equatorial belt. The subtropical high pressure belts are regions of calms. Out of them blow the trade winds in a south- or northwesterly direction (with reference to the equator), to be lost in the low pressure calms and doldrums at the equator. Contrast in pressure belts and the deflecting action of the earth's rotation cause them. The name is not derived from the reliability of these winds and their furtherance of commerce or trade, but is the one use of the otherwise obsolete meaning of "a course or way or direction." It is therefore a wind blowing in one direction or "trade," from the east toward the equator. Their area of chief effectiveness is between 3° and 35°, north latitude, and from the equator to 28° south latitude, shifting somewhat with the season, as all the surface winds tend to follow the vertical sun. They are most uniform over the oceans, where they are not modified by land

masses and mountains. Their importance in transportation has decreased with the decrease in sail-power. The development of air transport may again utilize them. Columbus by chance was brought by northeasterly trades to America.

Airplane transit of the Atlantic from America to Europe is facilitated by the northern belt of westerly winds, sometimes called anti-trades, because they blow in the opposite direction. As a climatic factor the trade winds are of the utmost importance. Moving horizontally with the earth, they undergo little change in expansion and hence their moisture-carrying power is not decreased. Blowing toward a warmer region, their moisture-holding power is increased. As a result the trades are dry winds and attended by a high percentage of clear skies. Similar reasons make the sub-tropic belts of high pressure very dry, in fact the driest in the world. Here the descending air is becoming warmer as it approaches the earth and is so devoid of moisture that it causes rapid evaporation from the earth's surface. The rapidly rising and cooling air of the equator on the contrary results in heavy diurnal rains. These equatorial, tropical and subtropical regions are thus seen to have the elements of remarkably little climatic change, of regular heavy diurnal rainfall near the equator, and increasing steady dryness toward the subtropic high pressure zones. This monotony of wind current is added to monotony of temperature and of rainfall. In the higher temperate zones, cyclonic storms serve an invaluable purpose in promoting changeable weather. In the low latitudes, only special winds induced by local land-water relations, hurricanes, and, to a very slight degree, thunderstorms, are available for this purpose. It is to be remembered that the trade winds in general are most constant on oceans and against easterly shores, and that their general climatic effect is greatly modified locally by high mountains or large land areas.

2. *Monsoons.* Following the suggestion in the last sentence of the preceding section, we find a general rule that large land areas cool more in winter and heat more in summer than do oceans. The general result is relatively high pressures in winter and low pressures in summer. Summer continental rains result from the inflow of moist air currents from oceans into these low pressure areas. In the huge expanse of Asia, these winds and rainfall conditions are exaggerated. Even in southern Persia and western India, annual temperatures have a 100° range, while in Siberia the range may amount to 175°. (Huntington and Cushing, "Human Geography," 235). This is because of the huge size of the continent and results in a heavy inflow of warmer ocean winds in summer, carrying moisture, and a heavy outflow of drier colder winds in winter. These general currents are called monsoons, derived from the Arabic word "mausim," meaning a time or season. They are therefore seasonal winds. They are best developed in India. Because of their origin, there is little winter rain across India and parts of China, when their direction is from the interior. With the establishment of the summer monsoon from the south and southwest, rainfall is heavy. There is a singular regularity in the winter northeast monsoon and the summer southwest monsoon in India. This periodical wind is utilized in sail travel and commerce between India and the islands of the Indian Ocean and Africa. Since the southern tip of India receives the trade winds from the ocean, it receives also a fair winter rain. Otherwise India parches in drought until the summer monsoon brings the rain, together with great improvement of general health conditions. The monsoons entirely control the climate of southern and eastern Asia.

Local monsoons are found also in Australia, the southern United States, southern Africa, and the Gulf of Guinea and equatorial Africa, where to some extent they modify the trade winds.

3. *Hurricanes and Tornadoes.* Cyclonic storms are characteristic of the belts of westerly winds in latitudes 35°–70° north and south. They are responsible for the rainfall and healthful variability of these zones. In the belts of the trade winds severe storms of a cyclonic type occurring at irregular times are called hurricanes. Very severe storms of a more limited area and concentrated nature are called tornadoes. The nature of these latter storms has been best studied by I. M. Cline (Tropical Cyclones), whose description is followed here. Wind forces at the earth's surface represent a combination of (1) those forces, modified by resistance encountered, which act on the inflow of air toward the cyclonic center, together with (2) the general air current in which the entire storm is moving. The tendency to spiral incurvature around the center is greatly modified in travelling cyclones (hurricanes) and is not uniform toward and around the center as usually described. There is, however, a symmetry of isobars for a considerable distance from the center. Winds in the right rear quadrant tend toward the direction in which the cyclone is moving. In the right front quadrant, the inclination or incurvature toward the center is decreased, and the average path becomes equidistant from the center. On the left, the winds come around with increasing inclination toward the center as they pass to the rear, curve into and take the direction of the winds of the right rear quadrant. Thus the essential feature is that the winds at all elevations up through the level of the cirrus clouds move forward in the same general direction in which the cyclone is moving. Thus the momentum of the general air current is added to the velocity and strength of the cyclonic winds of the right rear quadrant. This causes the sustained velocities so characteristic of that portion of hurricanes. Thus it is evident that danger and damage lie in the right rear quadrant while the left side is harmless. The right front quadrant is not so severe as the rear quadrant.

The general path of the storm is determined by air currents in the cloud levels. These in turn are greatly influenced by adjacent anti-cyclonic areas of high pressure. While high pressure areas augment the air current in which the cyclone is travelling, it will continue to advance. If high pressure areas oppose it, the cyclone gradually fills up and disappears. Cline's study of the isobars of three major cyclones showed them to be nearly circular from the center out to the isobar of 29.4 pounds' pressure. Beyond this there was a crowding on the one side and a spreading on the other.

Rainfall is very light in the rear half of a cyclone (hurricane) and heaviest sixty to eighty miles in front and to the right of the center. Relation of land and water areas controls the intensity of rainfall but does not affect its position in the cyclone. Temperatures show little variation. The source of rainfall as well as of cyclonic energy lies in the winds of the right rear quadrant. In the larger cyclones these air streams have a depth of five or more miles, a width of 250 to 400 miles, and a length of 400 to 800 miles in the line in which the cyclone is moving. The storm as a whole advances from 8 to 16 miles per hour and the winds of the right rear quadrant come into the right front quadrant with sustained velocities near the earth of 80 to 100 miles per hour. For 400 miles to rear of the center, velocities of 30 to 40 miles per hour may prevail. From the dynamic point of view the momentum of the great wind currents is more important than the relative positions of high and low pressure. There is low pressure and calm at and near the center. The

intensity of tropical cyclones is chiefly affected by low latitude and abundant sources of moisture. They are fostered by the extreme differences in temperature between land and water areas in the tropics.

The tropical cyclone is preceded by a period varying from several hours up to two or four days by heavy tides and storm waves in the ocean. These may be 500 to 1,000 miles distant from the center of disturbance and often are extremely severe and destructive. The tidal rise precedes fall in the barometer and is an important means of predicting the intensity and direction of a tropical cyclone. Such a storm tide means simply a rise in tide and water-level.

Tropical cyclones were first termed hurricanes in the West Indies, from the Caribbean word "huracan." The term then was used in the East Indies and the China seas, where the word typhoon is also applied. Tornadoes, small severe twisting cyclones, are especially common in the Mississippi Valley. Their area and duration are very small although they may do great damage in a narrow path.

Tropical cyclones of all types are important primarily for their great danger to human life and property. Their influence in moderating conditions of tropical climate is valuable but limited by their relative infrequency and narrow localization.

4. *Miscellaneous Special Winds.* The Föhn is a warm dry wind blowing down the Alpine valleys with great force and most common in winter. Very similar to this is the Chinook, which moderates the temperatures of the eastern slopes of the Rocky Mountains. It descends as a warm dry wind in winter, rapidly melting the snows, while in summer it cools the overheated temperatures. In southern France, especially in the delta of the Rhone, the cold dry Mistral blows down from the high pressure of the central French plateau to the warm Mediterranean Gulf of the Lion, even extending so far as Genoa. In Provence and Languedoc it is strongest and blows on an average of one day out of two. It is characterized by intense bright sunshine and piercing cold, and under special conditions becomes of stormy violence. Precisely similar to the Mistral is the Bora which blows on the Dalmatian and Istrian coasts of the Adriatic. From December to February the upper Guinea coast is visited by a hot, very dry wind from the Sahara carrying a heavy haze of red dust, called the Harmattan. Its extremely parching quality leads the natives to anoint themselves with grease during this season. It really belongs in the group of Sirocco winds.

Much confusion exists in the use of the word Sirocco. One type under this heading is the ordinary wind of the Mediterranean winter rainy season. The more widely used meaning, however, especially in Sicily and southern Italy, refers to the dry winds from the Sahara, laden with dust and sand. In the general region of the Mediterranean there are many local names for winds of this type, as Simoon (especially in Syria, Algeria and Arabia); Khamsin (filling the Egyptian air with sand in March, April and May); the Leste (in Madeira, drying the country-side and filling the air with fine red sand); the Leveche (wrongly called the Solano, a dry hot wind blowing on the Spanish Mediterranean coast).

Local peculiarities of land relief give rise to many winds of local importance, too numerous to list, like the "Wind of a Hundred and Twenty Days," in Eastern Persia, that blows for 3 to 4 months, distorting vegetation and making human life arduous. Such steady hard winds are deadening to human initiative and comfort, and produce irritability and even irresponsibility. The discomfort, apprehension, restlessness, nervousness and over-stimulation experienced in many storms and winds may be a com-

posite of actual pressure with poorly understood changes in the electrical and magnetic state of the atmosphere. Under tropical conditions, monotony of any sort is among man's greatest foes. Monotony of wind, of rain, or of temperature is equally disastrous.

5. *Wind Power.* This section can not be closed without commenting briefly on a situation of considerable weight in the future of the tropics. Steam-power from coal and oil, electrical power from steam and water, have come to occupy a primary position in twentieth century civilization. Wind power has been relatively neglected where formerly it was almost man's only source of energy. With the great prevailing winds of the tropics and the special local winds of fair reliability and force, it may well be that utilization of wind power can be made a productive economic asset in many regions now backward because of lack of power for industrial pursuits.

Ocean Currents

Air friction on the surface of the ocean sets in motion currents whose momentum increases in proportion to the strength and steadiness of the winds. Consequently in the region of the trade winds we find the strongest movements in the water, called the equatorial currents. These are deflected by the continents. The Atlantic north equatorial current is joined by half of the south equatorial current, which divides at Cape Roque, and swings into the Gulf of Mexico. It leaves the gulf through the Florida-Cuban strait and as the Gulf Stream flows northward until deflected by the eastward continental extension, by the Labrador current and by the zone of westerly winds, it swings across the north Atlantic toward Europe, where it spreads out as the Atlantic Drift, warming the entire western coast. In the Straits of Florida this is the strongest and most definite of the ocean currents, narrowing to a width of forty miles, with a depth of 2,000 to 3,000 feet and a speed of five miles per hour.

For the general trend of the major currents a special text and maps should be consulted. In each of the great oceans, there is a general current whirl set up similar to that of the north Atlantic. Ocean currents exercise a profound influence on climatic conditions, by carrying warm water into cooler areas and *vice versa,* thus in turn affecting air temperatures over them, influencing winds, evaporation, precipitation, and diurnal as well as seasonal changes. The high specific heat of sea-water allows minimal diurnal changes in temperature, thus making it a modifying factor in continental climates. Its heat is received entirely from the sun.

Cosmic Meteorology

Cleveland Abbe has excellently summarized this subject in the following words: "Under this title (Cosmic Meteorology) have been included all possible, plausible or imaginary relations between the earth's atmosphere and interplanetary space or the heavenly bodies. The diffusion to and fro at the outer limit of the atmosphere, the bombardment by ions from the sun, the explanation of auroral lights and magnetic storms, the influence of shooting stars and comet tails, the relation of the zodiacal light and the Gegenschein to the atmosphere, the parallelisms between terrestrial phenomena and the variations of the solar spots and protuberances, the origin of long or short climatic periods, the cause of special widespread cold days, the existence of lunar or solar gravitation tides analogous to oceanic tides, the influence of slow changes in the earth's orbit or the earth's axis of rotation—all are grouped under cosmic meteorology. But, in the writer's judgment, these matters, while curious and interesting, have no appreciable bearing on the current important questions of atmospheric mechanics." These matters must be rele-

gated to the physicists for further study and information. Such is true, for instance, in the case of the cosmic rays, recently discovered by R. A. Millikan, whose intensity is tremendously greater than that of X-rays; which are appreciably absorbed by the atmosphere though capable on mountain tops of penetrating six feet of lead, and which may eventually prove to be closely related to problems of altitude sickness and physiology.

Man's Best Climate

We have first to decide on a definition of the best climate for man and then estimate the approach of any tropical conditions to this standard. The pleasantest climate may not be the most healthful or the most effective for physical and mental vigor. Huntington deduces certain criteria for the climate most favorable for work and health, along the following lines. The mean temperature should not exceed the physical optimum of about 38° F. An annual average of some 51° would therefore be most desirable. As general examples of this temperature, Huntington notes England and the Pacific coast of the United States, where western breezes blow. But to proper temperature must be added moderate humidity. Wide temperature variations by seasons are important and usually are accompanied by wide diurnal variations. The influence of cyclonic storms has been noted.

It is evident that the tropics are seriously deficient by each of these criteria. A review of history again drives us to the conclusion that tropical environment in general does not provide the best climate for man's health, advancement or continued pleasure. When we turn to the poorly understood factors of insolation, magnetic conditions, social contacts and psychologic racial reactions, we have, apparently, further evidence of undesirability. Even tropical highlands offer definite hazards and handicaps. For white man or even for natives of temperate climates in general, we can not now assume an ability to maintain health, physical or mental vigor or to procreate healthy children who shall grow to mentally and physically vigorous adulthood in any tropical climate. The student of this subject should review Huntington's discussion of his map of climatic energy ("Civilization and Climate").

Conclusion

Willing or not, man's future on this planet requires the utilization of the tropics. He is therefore faced by the necessity of adapting himself to tropical climatic conditions in order to provide for his own future. This imposes the burden of a more rigorous study than heretofore of tropical climatology, which, unlike positive disease causes, can not be controlled, and therefore must be robbed of its dangers by means of accommodation thus far but poorly understood.

THE TREND OF MODERN PHYSICAL SCIENCE

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WE may approach this subject by a comparison between the physical world picture of the end of the nineteenth century and the present picture. Toward the end of the period of Helmholtz and Lord Kelvin the material universe was considered as made up of material particles, atoms, molecules, electric charges and magnets imbedded in a universal ether, in which the electric and magnetic energy have their seat and in which light is propagated in the form of waves. The physical space was nearly absolute; time was altogether absolute and independent of space. One universal clock gave to every observer the same time, while one measure stick could be used for all measurements, independently of time and motion. Forces are considered as physical realities. In gravitation we had, since Newton, action at a distance, while in electricity and magnetism the action took place from point to point through the ether along definite lines, the lines of force of Faraday and Maxwell. The methods of theoretical physics were those of total and partial differential equations; mechanical models were used for an intuitive understanding of the physical phenomena. The principle of causality was essentially the old one: If the position and velocity of the material particles are given in a given moment then they can be uniquely determined by means of the differential equations in every following moment; or, more generally, if magnitude and rate of change of the states of the material universe are known in a given moment of time, then they can be determined mathematically for every later moment. Theoretical physics was sharply divided into three departments: dynamics with the fundamental units, centimeter, gram and second; electrodynamics with two further units, electric charge and magnetic pole strength; thermodynamics with one further unit, temperature, and the phenomena of these fields were governed by Newton's equations, by Maxwell's theory of the electromagnetic field, and by Carnot's principle of the second law of thermodynamics. Theoretical physics was a sunny garden under the heaven of mathematics. Two principles especially seemed to dominate all physical phenomena, that of least action and that of probability in the heat phenomena. Though the division of the phenomena into three departments was artificial, violating our feeling of the unity of nature, in spite of several logical defects that period of physical sciences is now rightly called classical.

The classical literature of continental Europe was followed by the romantic period and the classical theoretical physics gave way to the present theory which has many romantic features. Let us now try to outline the present world picture as it has emerged from the theory of relativity and the quantum theory of light phenomena, theories which determine the present trend of physical sciences.

Space and time have become relative and closely linked together. The physical phenomena reside in a four-dimensional non-Euclidian continuum. An

infinite number of clocks and measure sticks are necessary for the physical measurements, but they are related in definite ways. The ether has disappeared. Matter consists of isolated positive and negative charges. Matter is reduced to electricity. Chemistry with all its wonders has become a department of electricity. The electric charges have their seat in that four dimensional continuum of relativity. Every motion is relative, even rotation. Whether a glass filled with water rotates on a table or whether the whole universe rotates about it, the observed phenomena are the same. The centrifugal force and the force of gravity are only fictive forces; indeed, they have disappeared altogether. Instead of forces we have to consider the curvature of a space-time continuum, in which all motions take place along geodesic or shortest curves. Dynamics is reduced to kinematics. By a fortunate circumstance Newton's equations with their forces can still be used as a first approximation to the physical reality. Maxwell's equations are still retained as rules of calculation. So the trend is away from mechanical models and intuitive understanding toward a mere algebraic formulation or analytic expression of the laws of nature. But in the theory of relativity the absolute laws of nature are more deeply comprehended than in the earlier theories; anthropomorphic features such as forces have been eliminated and the whole theory is a beautiful logical structure of sublime height.

Entirely different is the present quantum theory in its various phases. It involves a large variety of phenomena, and is in sharp conflict with the older continuum theory as well as with relativity. This theory is due to M. Planck, who in 1900 introduced in the theory of radiation of the black body a new constant h, so that an elementary oscillator like a small antenna in wireless telegraphy emits light only in definite quanta in a discontinuous process; the energy of the oscillator changes by a quantity which is equal to the constant h times the frequency of light emitted. So Planck was able to account for the radiation of light from hot bodies, such as the filaments of incandescent lamps. Since the beginning of this century we have had two conflicting theories of light: the wave theory for the geometrical phenomena of light, reflection, refraction, dispersion, polarization, interference, diffraction and the rotation of the plane of polarization and the quantum theory for the emission and absorption of light, and for the electrical and chemical effects of light. Whenever light arises or disappears, it behaves as if it were made up of particles, $h\nu$, but when once freed from the bonds of matter it seems to propagate in waves. In the sources and sinks light seems to consist of definite units, but in the space between the sources and sinks it behaves as a wave motion. This property of light is directly illustrated by the photoelectric effect. When light falls on alkali metals, for example, electrons will be emitted. Their number depends on the intensity of light, their initial velocity on the color or frequency of light. No matter how weak the incident light may be, the electrons are emitted with the same velocity for a given color of light, just as if the light consisted of definite particles whose energy only depends on the color or frequency of light. And as in the emanation theory of light the intensity decreases with the square of the distance from the source, so in the photoelectric effect the number of electrons emitted decreases with the square of the distance from the source. The intensity of light only affects the number of electrons emitted, not their velocity; the color of light only affects the velocity of the electrons. This contradicts all mechanical explanations on the basis of a wave

theory. In the case of electrons emitted under the action of Röntgen rays, the effect is still more pronounced. It looks as if the whole energy of a moving electron was transmitted through the Röntgen ray to another electron originally at rest without loss. A mechanical analogy would be this. A stone falling from a certain height in the Atlantic in the neighborhood of New York would produce a system of waves spreading throughout the ocean and reaching the coast of England would raise a stone of the same weight to the same height! Moreover, it has recently been found that in the scattering of Röntgen rays, the hardness of the rays changes, as if the incident ray had a definite momentum and energy and as if this light particle collided with an electron according to the laws of conservation of energy and momentum.

Niels Bohr has developed a quantum theory of the atom, especially of the hydrogen atom, on the following assumptions. The atom consists of a nucleus of positive electricity, which contains most of the inertia of the atom. Around this nucleus an electron of the same but negative charge circulates in definite orbits. According to our experience with electric waves such a revolving charge ought to emit light. Bohr, however, assumes that this sort of electricity in the atom does not radiate in the stationary orbit, which is either a circle or an ellipse. He assumes further that the stationary orbit is determined by Coulomb's law of electric action and by the quantum relation that the moment of momentum of the revolving electron is equal to the constant h multiplied by an integer, divided by 2π. Finally Bohr assumes that light is given out by an electron jumping from one stationary orbit to another one. This theory has had great success in the interpretation of the line spectra of chemical elements. Bohr has extended the theory to the other elements, assuming that the higher elements are formed by the addition of one electron after another to the corresponding nuclei. So we have gained a new interpretation of the periodic properties of the chemical elements. Additional principles like those of selection, of correspondence, of exclusion, the adiabatic hypothesis have been introduced until a new quantum theory of matter appeared like a new science of considerable size and importance. A very interesting idea, that of space quantization, has been introduced in the classification of the various groups of lines of the elements. And the magneton of the hydrogen atom has been determined recently by means of experiments suggested by space quantization of electron orbits. The various successes of the theory, the explanation of the Zeeman effect, the Stark effect, the resonance and ionization potentials, the fine structure of the hydrogen lines, the coordination of the complicated multiplets, led many physicists to overlook the defects of the theory. Special difficulties arose in the case of the simultaneous action of an electric and magnetic field on the radiation of the atoms.

Within the last two years two new theories have appeared, both of which eliminate the only intuitive character of Bohr's atom, the microcosmic planetary system of electrons in the atoms. One of these theories is a pure discontinuum theory, the other a vigorous continuum theory, and the results of both theories seem to coincide exactly. Such is the power of mathematics. The continuum theory of Schrödinger introduces wave mechanics; the orbits of the Bohr atom are replaced by characteristic or auto-vibrations in a transphenomenal space of which we have no intuitive experience. The quantum conditions of the older theory correspond to the boundary conditions of the problem. This reminds us of the harmony of numbers

in Pythagoras lyra. The integers of the triad of the vibrating string are due to the boundary of the string. The vibrations in the atom, however, are metaphysical or transphenomenal. The electron in the atom itself is not a point charge, but its charge is spread throughout the atom or the whole space. And its electricity spins around an axis giving rise to the magneton. It has only four degrees of freedom instead of six, as we should expect from any mechanical analogy.

If anything is not intuitive, it is this atom of Schrödinger. And so we see in relativity as well as in the quantum theory a tendency away from mechanical models toward a purely mathematical formulation of the laws of nature. Maxwell's equations, without an ether and without lines of force, are for me merely mathematical rules of calculation. When we speak of the velocity of light in the theory of relativity, we admit that nothing moves! In a similar way the new theories of the atom are only rules of calculation; Schrödinger speaks of oscillations in a transphenomenal space without even saying what moves.

The pure mathematician still uses models in geometry, he constructs even models of non-Euclidian spaces; the chemist, using a model for the benzene ring and its derivatives, has built one of the richest departments of natural sciences, organic chemistry, but the physicist between the mathematician and the chemist seems to be doomed to resign to all intuitive thinking by means of models. This may be, of course, a temporary fashion of the present theoretical physicists. Nevertheless, I think we shall continue in our instructions to use lines of force as models for electric and magnetic phenomena, rays of light in geometrical optics, valence lines in the chemical compounds as before, forces in mechanics, lines of flow and equipotential surfaces in hydrodynamics.

If theoretical physics should be reduced to a certain number of rules of calculation, without any intuitive understanding of the phenomena by mechanical models, nevertheless I believe it is well to continue to use mechanical models not only as illustrations, but also as tools for further investigations. Some of the most important discoveries have been made by mechanical analogies. Carnot arrived at the second law of thermodynamics by a mechanical analogy; Faraday, the greatest discoverer in physics, was guided by models; Maxwell used mechanical principles in the deduction of the laws of the electromagnetic field. Newton's emanation theory of light led to the conclusion that a beam of light from a fixed star, passing across the limb of the sun, would be bent, and this conclusion should have been tested independently of relativity.

With and without models, deep problems remain to be solved. The abyss between the continuum theory of relativity and the quantum theory still remains open, the constant h has not yet been explained or correlated with Maxwell's field theory; the theory of light is still covered by a dark cloud. But no matter how difficult the problems may be, how contradictory the present theories, the physicists as well as every scientist has the religious conviction that nature is unity and that the laws of nature form a harmony.

THE PHILOSOPHICAL BACKGROUND OF RELATIVITY

By Dr. MORTON MOTT-SMITH

THE distinction between the old philosophical and the new physical relativity is not well understood. Consequently, every now and then the claim is pushed forward that so-and-so has anticipated Einstein, because somewhere in his writings he made some general remarks about relativity, or described in detail the relativity of motion prior to 1905, the date of Einstein's first contribution. Or else it is claimed that there is nothing essentially new in Einstein—that ideas of relativity were common property long before his day. It is time that both these pretensions were punctured.

Four stages of relativity may be distinguished, one philosophical and three physical. The first dates back to the very beginnings of man's reflections concerning the nature of human knowledge. Already Protagoras, "Greatest of the Sophists," contemporary of Socrates, who lived in the fifth century B. C., said: "Man is the measure of all things." He taught that there is no absolute truth, that we know things only as they appear to us through the senses. We have therefore no direct knowledge of the things themselves, but only as they appear to us, colored and distorted by their passage through the senses. What is great to one man is small to another. Man measures and judges everything in relation to himself. The human element in knowledge is inescapable.

In the seventeenth century A. D., the same thought was again taken up by John Locke. He showed that all knowledge arises through the comparison of our sense-ideas, one with another, in respect to their likeness or unlikeness, or other relations in which they may stand to one another. We know a thing only through its relations to other things, and these again by their relations to still other things, and so on. Hence in the end we know only relations. The things themselves forever elude our grasp. In their true and absolute natures, if such exist, they are completely beyond the human understanding. For Locke, all knowledge was derived from experience. "There is nothing in the mind, which was not previously in the senses," he said; and Leibnitz added, "except the intellect itself." The intellect itself contributes something, Leibnitz taught, which is not derived from experience—namely, logic and mathematics. But Kant showed that these are applicable only to the material of experience. When applied to anything else, they inevitably lead to irresolvable contradictions (antinomies). Hence "Pure Reason" provides no bridge to the thing themselves, as they really are before they pass to us through the senses. So Kant divided the world into two parts, the phenomenal and the noumenal, the knowable and the unknowable.

One of the main theses of Herbert Spencer was the relativity of all knowledge. Like Kant, he divided the world into two parts, the knowable and the unknowable, the relative and the absolute. All the former belonged to science, all the latter to religion, or to whomever else might care to claim it.

Of course not every one accepted this philosophy. From Protagoras onward men have incessantly endeavored to get

at this entrancing realm of the absolute by some means or other—by pure reason, intuition, faith, inspiration or by some other mystic means. But whatever may be the final outcome of their endeavors, this much is certain, and may be regarded as the one positive contribution of the critical philosophy—all *scientific* knowledge is relative. Logic and mathematics are tools which are applied to the data of experience, which alone furnishes the materials. All else is *un*scientific, and may well be left to those dreamers and mystics who delight to roam the realm where all positive knowledge is impossible, and no facts may refute them.

A part of the relativity of all positive knowledge is the relativity of all knowable motion. This fact was discussed and fully established centuries before Einstein lived. It was very clearly set forth by Descartes in his "Principles of Philosophy" (ii, Par. 18, 1644) in the following words: "In order that the place (of a body) may be determined, we must refer to other bodies which we may regard as immovable, and accordingly as we refer to different bodies it can be said that the same thing does, and does not, change its place." He then gives the illustration of a sailor on a ship, which has been so much used in this connection. The sailor moves on the ship, which moves on the seas, on a moving earth. Descartes shows that finally to determine the true motion of the sailor, we must "determine it with reference to some immovable points in the heavens. But, if we concede that no truly immovable points are to be found in the universe, as I shall hereafter show is probable, our conclusion will be that there is nothing which has a fixed place except so far as it is determined in thought."

Very much the same exposition was given by Newton in the scholium at the end of the first chapter of the Principia (1686) using the same illustration of the sailor and the ship. But contrary to Descartes he believed that "it is possible, that in the remote regions of the fixed stars, or perhaps far beyond them, there may be some body absolutely at rest." But as there is no way to know that this body is at rest it would be of no use to us. "And so, instead of absolute places and motions, we use relative ones; and that without any inconvenience in common affairs." "Yet," he believes, "the thing is not altogether desperate." For he thinks that the forces required or developed by motion, particularly rotation, may be used to distinguish between absolute and relative motion. In short, although the distinction is impossible by direct observation or measurement of motions, it may be possible indirectly through some physical effect. Of this we shall hear more presently.

In 1765, the great mathematician Euler, in his "Theory of the Motion of Solid or Rigid Bodies" (Chapter I), after again discussing the sailor and the ship, said: "The same body which is at rest with respect to the body A is in various motion with respect to other bodies. . . . Therefore motion and rest are distinguished merely in name and are not opposed to each other in fact, inasmuch as both may at the same time be attributed to the same point, according as it is referred to different bodies. Nor does motion differ from rest otherwise than as one motion differs from another." As later physicists have put it —rest is a special case of motion.

In the second chapter, Euler then goes on to discuss most interestingly the question whether, if there were but one body in the universe, this body could properly be said to be at rest or in motion. He answered emphatically—yes. Suppose all the bodies in the universe were removed one by one, until only the earth were left. Would that destroy the motion of the earth? By

no means. It would merely remove our every means of ascertaining that motion, but the motion itself would not and could not be destroyed by such an act. The conclusion is strengthened if we apply, as Euler did, Newton's first law of motion. Whatever motion the earth had at the moment of the removal of the last body, must continue thereafter unchanged.

Now if the material universe is finite, as many believe it to be, it constitutes just such a Eulerian single body in space. We can neither affirm nor deny that it moves. But such a motion has no meaning for us. We can only determine the relative motions of its parts.

All of those quoted, it may be noted, while denying the knowability of absolute motion, tacitly assume its existence. Herbert Spencer, in his "First Principles," Par. 57, 1860, specifically argues for its existence. Though he declares it to be not only unperceivable, but inconceivable, incomprehensible and unknowable as well, he maintains that "in this very process of concluding that the motions we perceive are not the real motions, we tacitly assume that there are real motions. . . . that there are fixed points in space with respect to which all motions are absolute; and we find it impossible to rid ourselves of this idea." He uses also the ship illustration.

A diametrically opposite conclusion is drawn by J. B. Stallo, "Concepts and Theories of Modern Physics," p. 200, 1881. On the basis of "the universal principle of relativity" which he proclaims, he affirms that "the annihilation of all bodies but one would not only destroy the *motion* of this one remaining body and bring it to rest, . . . but would also destroy its very *existence* and bring it to naught." For according to Stallo, not only the knowability but the very existence of a body depends upon its relations to other bodies. Destroy the relations and you destroy the body. "A body can not survive," he says, "the system of relations in which alone it has its being."

Finally Hudson Maxim in "The Nature of Matter" (*Scientific American Supplement*, May 11, 1889) came also to the conclusion that absolute motion does not exist. "Let us now conceive," he says, "of but one of these ultimate solid atoms as existing entirely alone in all space. . . . It could have no motion in any direction, for space of itself without limit is without direction, and no place in space could have position relative to the rest of space—hence position and place as relative to but space are impossible, therefore, a single ultimate atom existing alone in space could have no motion, as it could not alter its position, having no position or place to change." It would seem fairly obvious that a body, "having no position or place," that is a body that is nowhere, simply does not exist. But Maxim did not advance to this conclusion as Stallo had done. Both Stallo and Maxim deny not merely the knowability of absolute motion, but its very existence. For this they have been credited by some with having anticipated Einstein. But the conclusion is hardly justified. To deny that a single body in all space can be in motion is to affirm that it is at rest. And this rest is absolute rest. To affirm absolute rest is as pernicious as to affirm absolute motion. To deny either is to affirm the other. We here fall into one of those antinomies which Kant taught us is inevitable whenever we endeavor to penetrate that vacuum that surrounds the world of experience. The only escape from this dilemma is the one that Stallo took, *viz.*, to deny the possible existence of such a single body.

However we are not here concerned with these metaphysical quibbles. Let the philosophers wrangle over them. The lesson for us to learn is that absolute motion whether it exists or not is

totally unknowable. Nor does it matter to the scientist whether it exists or not. The only kind of motion that he can deal with is relative motion, the motion of one body with respect to another. This we may concede the philosophers to have definitely established. The conclusion depends upon no experiment, but results from analysis of the knowing or perceiving process itself. No experiment can weaken or strengthen it.

All this was known long before Einstein stepped upon the stage, as our quotations have shown. It has nothing whatever to do with the modern physical theories of relativity. The latter are not derived nor derivable from any philosophical principles. They were not foreseen nor foreseeable by any philosopher. They resulted solely from certain particular experiments. Each of the three stages, in fact, had to fight its way against opposing general notions supposed to be rooted in common sense. No philosophical theories can strengthen or weaken them. Future experiments alone can decide whether they shall continue to stand or not.

What then is the distinction between philosophical and physical relativity? Philosophical relativity, we have seen, is concerned with the knowability and existence of absolute motion. The former has been decided in the negative. The latter is undecided, but irrelevant. Physical relativity is concerned with the problem whether there is any indirect means of determining the motion of a system by means of physical phenomena taking place within the system. That is, can we detect its motion without looking outside? It matters not whether the motion we so seek to detect is absolute or relative. Hence this is a purely physical question which can be settled only by experiment and is independent of all philosophical considerations. We have seen that Newton already asked this question in his scholium, thinking there might be some such means of detecting the absolute rotation of a body. But his argument was fallacious.

The first stage of physical relativity resulted from the experiments of Galileo prior to 1638, although the relativistic significance of them was not appreciated until more than two and a half centuries later. Up to this time it had been supposed that force is required not only to produce, but also to maintain motion. Rest was taken to be the natural state of bodies, to which they invariably reverted as soon as the forces that impelled them ceased to act. Since the earth was supposed to be stationary, this rest was absolute rest. Hence it became an insoluble riddle as to why a stone continues to move for some time after it has left the hand of the one who flung it. (See Descartes, "The World," Chapter VIII). So long as the hand is pushing the stone, it is easy to see that the stone should move, but why does it continue to move after the push of the hand has ceased? In short, why does the effect continue after the cause that produces it ceases to act? Now, Galileo did not answer this question. He merely ceased to ask it, based, as it was, on a false assumption. Knowing that the earth is moving, he knew that the stone was also moving before ever the man acted upon it. The effect of his action was not to produce motion *de novo*, but merely to alter a motion already existing. If the man had thrown the stone in the direction contrary to that in which the earth is moving, he would not have created any new motion, but would have detracted from one already existing. So Galileo reversed the question. Rather, he asked: "Why does the stone once flung ever cease to move with its new velocity?" The answer he found in the resistance which the air opposes. And so with all other bodies, that sooner or later come to rest with respect to the

earth, he found the causes in the greater or less resistances which they encounter. The more and more these resistances are diminished, the further and further a given impulse will carry a body. Suppose the resistances could be reduced to an absolute zero—what then? Galileo answered that the body would continue with unaltered velocity and direction forever. And so was born the law of inertia, or the first law of motion, as Newton afterwards called it. This was a revolution of prime importance—the end of old notions, the birth of new ones. A static world gave way to a dynamic one. Not rest, but motion, is the prevailing state. All bodies continue in the state of uniform motion in a straight line, unless compelled by force to alter either their velocity, their direction, or both. The effect of force is to alter motion. Force is required to stop as well as to start a body, to diminish as well as increase its velocity. No force is required to maintain motion.

Here is a state of affairs surprisingly different from what was supposed to obtain, and what is even now supposed to obtain, by those who have never heard of, or having heard, have failed to understand the full significance of the law of inertia. Could any philosopher have predicted it? Did any philosopher foresee it? The answer is: No. It was an experimental discovery. Who could have dreamed that physical motions depend upon differential equations of the second order, as this law demands, instead of equations of the first order, as the previous views require?

The relativistic significance of this discovery may be explained as follows: I use the stock illustration of the train, because there seems to be nothing better. The train, in fact, is getting to be as indispensable to physical relativity as the ship and sailor were to the philosophers. Suppose you were shut up in a windowless train running with uniform speed on a perfectly smooth, straight track, absolutely without noise or jar. There is no mechanical experiment that you could try that would in any way disclose your motion. In other words, everything would take place exactly as though you were standing still. If you throw a ball vertically upwards, it falls vertically downward into your hand again. It is not left behind by the forward moving train. For, by the first law of motion, the velocity of the train, which the ball had when held in your hand, is preserved unaltered, after leaving the hand. So, despite the fact that the ball is no longer attached to any part of the train while in the air, it continues to move forward with the same velocity as the train, so that it keeps constantly vertically above the hand, although with respect to the ground outside, it describes a parabola. If you open the window of a moving train, and throw a bottle or something directly at a telegraph pole, the moment it comes opposite, you will not hit the latter. The bottle, preserving the motion of the train which it has, will, except in so far as retarded by the wind, remain directly opposite the window, and, pursuing a diagonal course with respect to the ground, pass in front of the pole. Similarly, the flier, who drops a bomb from his aeroplane, the moment he comes directly over the target, will find that the bomb remains directly under the plane throughout its fall and hits the ground in front of the target, the same distance, or nearly so, that the plane has meanwhile traveled.

Now, the shut-up train, or any similar box, moving with uniform rectilinear speed, constitutes what is called a Galilean system of reference, and this first stage of physical relativity is called the mechanical relativity of uniform motion. It is also called Newtonian or classical relativity. It asserts that by no mechanical experiments, performed in a Gali-

lean system of reference, can the uniform rectilinear motion of that system be detected.

Now, of course, we shall never have the advantage of a perfectly smoothly running train with which to experiment. But in the earth itself we have a superb example of a body moving so silently and evenly that its motion is utterly imperceptible. In fact it was for this reason that its motion was so long unsuspected. Here we are being carried along far faster than any express train, or even than the swiftest projectile, yet totally unaware of the fact. All our work, building, surveying, engineering and even delicate laboratory experiments are done and take place exactly as though the earth were standing still. Hence the earth itself affords an excellent Galilean reference system. Yet it is not quite perfect. Its course is not quite straight. A point on its surface describes a great circle some six thousand miles in diameter in temperate latitudes. By means of the Foucault Pendulum, the gyroscope and a few other delicate methods, this motion can be detected because of its curvature, although the deviation from a straight line is less than a foot per mile. But in its motion around the sun, the earth swings in an orbit 186,000,000 miles in diameter. The deviation from a straight line is here less than four ten-thousandths of an inch per mile, which is a far straighter line than any surveyor could lay out. Hence up to the present no instruments have been constructed sufficiently delicate to detect this motion. From this it appears that mechanical relativity does not apply to non-uniform motion. The latter betrays itself in the altered behavior of our instruments.

The second stage of physical relativity resulted from the Michelson-Morley experiment in 1886. This endeavored by an optical method to detect the motion of the earth with respect to a hypothetical surrounding ether, supposed to be stationary. It has been claimed that this was an attempt to determine the absolute motion of the earth through space. It was nothing of the sort. Motion with reference to the ether is still relative motion. The universe as a whole, as has already been pointed out, constitutes a Eulerian body, whose motion through space would constitute absolute motion. But the motions of the various parts within that system with respect to some one part are relative. That the system as a whole might be moving in some unknown and unknowable fashion is no concern of the physicist, for he is perforce confined to what he *can* know. Nor does the failure of the Michelson-Morley experiment constitute empirical proof of the non-existence or unknowability of absolute motion. No empirical proof of these things can be given.

There is, however, a sense in which the physicist uses the word absolute which is different from the philosophical usage. Thus the physicist has the absolute and gravitational systems of measurement. The latter depend upon the unit of weight which varies from place to place. The former depend upon the unit of mass which is the same everywhere. So, also, he has absolute temperatures, measures, constants, etc. He simply means, more universal, less relative to particular or local things. His absolute is only relatively absolute, not absolutely absolute, like that of the philosopher. Hence he has degrees of absoluteness, which the philosopher has not. His highest degree is that which is the same for all observers however conditioned, *i.e.*, the universal empirical.

Now, if the stars are embedded in an all-pervading ether which is not affected by their relative motions, that would form an excellent reference frame to which to refer all motions. Such motions would be the same for all observers, however situated. They would, there-

fore, be absolute in the physicist's sense, but not in the philosopher's. The existence of these two uses of the word absolute has doubtless caused confusion.

The failure of the Michelson-Morley experiment showed that no such universal reference frame exists. Therefore, neither by mechanical nor by optical, or more generally by electro-magnetic, means can one detect the uniform rectilinear motion of the system in which he is situated. This is Einstein's "Special Theory of Relativity," 1905. It may also be called the complete relativity of uniform motion. It is, of course, supported also by other experiments.

Having thus established the complete relativity of uniform motion, it was natural that Einstein should advance to the consideration of non-uniform motion. This was conquered in 1915 by his "General Theory." Unlike the other two stages of physical relativity, this third stage was not an after-interpretation of experiments originally performed for quite other purposes, but resulted from first assuming the hypothesis, then seeking what modifications must be made in our physical ideas to conform with it, then devising experiments to test the assumption. As far as mechanical matters are concerned, he found that we already possessed what we needed, only it must be a little differently formulated. This he did in his principle of equivalence.

Let us go back to our smoothly running train. But instead of moving uniformly, let us suppose that the velocity is constantly increasing, everything else, however, being as smooth and silent as before. What will now be the experiences of the inmates? First of all, they will observe that there is a sort of drag upon everything toward one end of the car. A ball placed upon the floor will roll down toward this end with increasing velocity. A man standing in the aisle will have to lean toward the other end to maintain his balance. He will find it more difficult to walk toward this end than toward the other. The surfaces of liquids will stand at an angle to the floor. The plumb line will be similarly inclined. What will be the conclusion of these people with regard to their situation? Naturally they will conclude that their abode is resting on the earth in an uptilted position. And no experiment that they can perform will contradict this conclusion. Of course, some Copernicus might finally arise among them, and point out that the phenomena are equally consistent with the idea that their abode is moving in the direction of what appears to be the high end, with a uniformly increasing velocity. But he would probably be considered a crank. And his curious hypothesis could never be tested until some Galileo thought to bore a hole through a side wall and look outside.

In the same way, Einstein has shown that all the mechanical phenomena that we have been accustomed to associate with changes of motion can be equally well accounted for, and actually produced by the application of suitable forces and *vice versa*. Their indications are ambiguous. They can be accounted for in two ways. And these two ways are equivalent, that is, one is just as good as the other. And the only way to decide between the two is to observe bodies outside the system. Particularly illuminating is his discussion of rotary motion—the case that puzzled Newton and many others since. The existence of centrifugal forces does not necessarily imply rotation. They may be actual forces produced otherwise. We know, of course, that a plastic sphere when rotated will become flattened at the poles. But the mere existence of a flattened sphere does not inevitably mean that it acquired its shape by rotation—some one might have hit it with a hammer. In virtue of this principle of equivalence

we therefore already have mechanical relativity of non-uniform motion.

But how about optical and electrical phenomena? Here it was found that if the ordinary conceptions of the nature of radiant energy were true, one would have an infallible means of distinguishing between a field of force and a change of motion. The principle of equivalence would no longer hold. But if light had mass, momentum and weight, and in all other ways acted like a stream of material particles, then this would not be the case. We should then have complete relativity of all motion, both uniform and variable. The eclipse and the spectrum experiments decided in Einstein's favor.

In all this it makes not a particle of difference whether any of the motions concerned are absolute, in the philosophical sense, or not. Physical relativity does not depend on, nor is it a product of, philosophical relativity. It is something entirely new, discovered by experiment, unforeseen and unforeseeable by any philosopher. It stands on its own feet. And so long as the experiments on which it depends continue to support it, it will continue to stand. But if these should fail, it would have to be abandoned, and not all the philosophy in the world could save it. Likewise, philosophical relativity, the relativity of all knowable motion, stands on *its* own feet, on its own theoretical grounds. And it will continue so to stand, though all Einstein should fail.

ENTOMOLOGY IN RELATION TO INDUSTRY

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WHEN one speaks to-day of the science of entomology it is natural, especially for the scientist, to think first of the pure science, insects as animals, and consequently of the zoological connection rather than of the economic or applied phases. It is true of course that entomology had its origin in this way and for many years continued to be a strictly zoological science, but as entomology has gradually developed, by the very nature of the human and economic relationships involved, it has become more intimately associated with the economic and industrial problems of the world in which we find ourselves.

From the time that Dr. Harris, who has been termed the father of economic entomology in America, published his treatise upon injurious insects in 1841 to the present day, the development in this field of applied science has been remarkable. The greater part of this development, too, has taken place during the last thirty to thirty-five years. The problems have become more diversified and complicated and the interrelation of entomology to the fundamental and agricultural sciences has become more pronounced. This rapid development has been brought about chiefly by the applied phases of the subject and their application to the problems of life and industry, until at the present time the scope of the field has become so broadened that it touches and affects many phases of industry. The scientist who has not been working directly in the field is probably not aware of the vast numbers of different industries affected by insect problems, but when one begins to look about him to find those that are affected to more or less degree, the surprising thing is to find how few have escaped either slight or serious losses or have failed to be affected.

If we discuss rather briefly the various industries affected, we should probably mention first those directly concerned since their raw material is manufactured by the insect either as a direct product or in its attempt to pass certain life stages. Chief among these industries are, first, the manufacture and commerce in silk, dealing with all phases of this problem from the actual feeding and rearing of the worms to the weaving and selling of cloth. When we realize that 45,000,000 pounds of silk are produced annually with a value of approximately $200,000,000, we can estimate the numbers of individuals employed in these various processes. Second in importance is the manufacture of honey and wax by the bee. The honey crop in the United States is valued at something over $20,000,000 and the wax is valued at $4,000,000 annually. This has become an important commercial phase of insect work. Two other industries which might be included under this type and which would probably rank third and fourth, respectively, are those manufacturing shellac and cochineal dyes. Insects are responsible for or aid in the manufacture of both of these products.

In addition to those industries which deal chiefly with manufactured products of or by insects, the next great industry which is most seriously affected is that of agriculture. It is neither necessary nor advisable to discuss this subject at

length at the present time, but simply to state the problem in a very brief manner by saying that the farmer's task is to grow at a profit plants and animals to feed and clothe the peoples of the world. In doing so he is confronted with insect problems on every hand, these pests destroying his crops and parasitizing his animals. No plant or animal has yet been found which is absolutely free from the attacks of insects, and the average toll of all these products taken by insects is approximately 10 per cent. The loss to agriculture is enormous, being conservatively estimated at $2,000,000,000 annually. One of the most striking evidences of this loss is the recent $10,000,000 corn-borer appropriation, as well as the large sums appropriated annually for Japanese beetle, gipsy moth, Oriental fruit moth and similar problems.

We might consider briefly several of the industries which are outgrowths of the farm or whose business is built upon the manufacture or handling of farm products. All animal industries are of such a nature. Insect parasites attacking cattle affect our sources of meat supply by reducing the vitality of the animal and by actual destruction of the muscle in the case of parasites like the warble fly. In like manner the amount and quality of milk production is reduced, so that dairies and creameries are required to face the insect problem in regard to their supply as well as the possibility of insect infestation or contamination of their retail product.

All the leather and leather products industries are affected by insect parasites that puncture and eat holes in the hides. Where this occurs, scar tissue is formed which renders this portion of the hide worthless so that the value is greatly reduced. This is one of the most striking losses in the cattle industry at the present time.

The meat packing industries are affected by the insect problem in at least two ways: the attacks during the animal's life, and more especially the meat products after the animal is slaughtered. The soap manufacturing industries and all similar types where animal fats or oils are used in manufacturing various products are similarly affected. The fur industries suffer severe insect attacks. The external parasites of course are important in this respect during the life of the animal, causing diseases like mange and scabies, which destroy the animal's fine glossy coat. But the problem which causes most severe economic loss probably is the destruction of furs after they have been made into coats and other articles of clothing. Since this industry involves a considerable amount of wealth, and has been increasing rapidly and for the most part among a class of people who have no appreciation of the insect problem, the losses are enormous. The clothes moth alone, for instance, causes something like a million dollars of damage annually in Ohio. We must not forget either the total loss of life among animals due to insects transmitting bacterial or protozoan diseases from animal to animal and where in many cases the insect is the important factor since it is the only vector.

In discussing rather briefly the animal industries, cattle have been cited as an example, but all domestic animals on the farm, horses, sheep, hogs, etc., are similarly affected with various parasites and could be discussed at length in the same way. The poultry industry producing our supply of fresh eggs and the fowls for market is similarly affected by insect parasites, especially external types.

We might turn for a moment to glance at other industries handling agricultural products which are greatly affected by insect pests. All the canning factories should be mentioned in this capacity.

Vegetables of all types, small and tree fruits and similar products are handled by these factories. The canned goods industry, too, has become enormous since it provides so much of our daily food supply. To mention a specific example, in 1925 one canning factory in Essex County, Canada, where the corn borer has caused severe losses, was obliged to spend $250 a day for extra labor alone during the corn canning season, in view of the fact that certain types of machinery could not be used for corn infested with this pest. In the same manner we might mention, if time permitted, the losses to all types of vegetables and fruits caused by insects. In many localities and during various seasons aphids or other pests may cause the loss of entire fields of peas, beans, spinach, celery or other crops. The fruit losses due to insects are enormous, especially in view of some of our most recent importations like the Oriental fruit moth and Japanese beetle. All the pickling and preserving industries can be included in the same type of problem so far as insect losses are concerned.

The dried fruit industries and canned dried fruits have presented some puzzling problems of control. Dates and figs, apricots, peaches, apples, prunes, etc., suffer losses both during the growing season and storage. Fruits coming from Mesopotamia on grain freighters are seriously infested when they arrive and treatment is difficult. The storage problem is therefore becoming more serious in many cases.

The industries manufacturing grape juices and other fruit juices and fruit extracts, and the flavoring extract industries must consider the insect problems. We find that the insect infestations reduce markedly the sugar content of fruits and as a consequence the quality of the product is inferior and the value is greatly reduced. Fruit of this kind is often refused by these industrial plants even under a contract price.

The baking industries are affected directly in one way, due to the insects which attack wheat in the field or storage. In another way they are affected by insects infesting figs and other fruits. In the process of making fig newtons, for instance, the law no longer requires an insect-free product but states that the infestation of stored products insects must be below a certain percentage since it is practically impossible to keep them insect-free.

The English walnut, pecan and other nut industries are severely affected by nut weevils, case bearers and similar pests. All the sugar industries and those where sugar is used in manufacturing candy and other products must face the insect pests in the form of the sugar-cane insects, the beet leaf hopper, and many other field pests, as well as stored products insects common in candy and similar products.

Many industries are affected by the stored grain insects which belong to several groups. All granaries, flour and grain mills, grain elevators, cereal packing houses, warehouses, seed stores and even grain freighters on our high seas and all the industries handling these products have been brought face to face with the insect problems and have had to devise means and apparatus for intermittent control measures in these plants. To the average biologist it seems practically inconceivable that a small insect could become so abundant and such a pest as to clog the machinery of a mill and necessitate the closing of operations for a short period to eradicate these insects. But such has been our experience with several of the silk-spinning type of larvae and many of us have observed these conditions. These losses and costs due to destroyed products, loss of operating time, additional appa-

ratus and construction in anticipation of insect attacks are enormous.

The tobacco industry suffers serious losses by insect pests, both in the field and storage. In spite of the fact that this plant is the source of one of our most toxic plant poisons, certain insects seem to be able to consume it and to thrive upon it. The paper and paper board manufacturing concerns where straw and wood pulp are used as raw products must consider losses by field insects and wood borers of several types.

The building industries are affected probably most seriously by the termite problem. The architect must plan to use different materials in construction so as to counteract these attacks. In the modern home the wood work, the sills, hardwood floors and even the furniture are common objects of attacks, causing annual losses. Even fireproof buildings contain termite colonies in the small pieces of wood used to finish the interior. The cost of timber for all types of building construction has increased, and lumber is graded largely according to the amount of insect damage present. The wood boring insects are especially destructive to growing timber and this problem alone is causing much concern for the timber of the future. All the lumber and building industries must face the insect problem, both in the case of growing timber and after it is stored in the lumber yard, not to mention the houses that are constantly crumbling to pieces because the insects have destroyed the foundations. In addition we might mention the coal tar products industries and wood-preserving devices which are now being used.

Another enormous industry, the furniture business, is finding itself rapidly facing more and serious insect problems. The materials used in its manufacture must be more carefully selected because of these injuries, but the real problem is the protecting of upholstered and overstuffed furniture against the attacks of moths and similar pests of fabrics. Mohair cloth is especially susceptible to their attacks and by the very nature of the weave expensive furniture is frequently ruined before injury is noticed. This leads to the installation of heating chambers and similar devices to protect these articles of furniture, and adds a new industry which has been brought about by this demand for the control of an insect pest which has caused so much loss in the commercial world. The piano industry suffers losses by destruction of the felt pads and similar materials within these musical instruments requiring rebuilding and enormous losses in many cases. The carpet and rug manufacturing concerns suffer similar attacks and severe losses since slight injury reduces the value greatly. In like manner all the industries dealing with plant or animal fibers, such as cotton, hemp, wool or mohair, which are stored either before or after woven into cloth, must constantly consider the problems of the insect pest either in the growing stage of the plant or animal in the field or after these have been made into fabrics.

Many phases of the work of the tree surgeon and the landscape gardener are directed solely at insect attacks or are the result of previous insect infestations. When attempting to beautify the home surroundings or the estate the constant fight upon the insect must be kept in mind. The greenhouse industry, which is becoming a very important one, where cut flowers, winter vegetables and similar luxuries and necessities are raised, is one of the most difficult to accomplish since the conditions under glass favor rapid and abundant development of pests.

We might turn for a moment to glance at industries which seem so far removed in many cases from the insect problems that one would consider the insect a negligible factor. Certain engineering

projects might be placed in this group. Yet the very nature of engineering work takes the operators, surveyors and supervisors as well as many workmen into the most dangerous places as far as disease dissemination is concerned. Mosquito control itself is partially an engineering project. While considering this phase of the work, we must not forget that the Panama Canal stands as a monument to the success of a project of insect control. That it was built only after the mosquitoes had been controlled and all the engineering skill the world could produce was held at bay until that insect problem was solved.

The real estate business hinges in many cases upon this same problem. Land values are usually very low where mosquitoes or other similar insects are present in sufficient numbers to make normal living conditions almost impossible. When the insect is controlled, the real estate values immediately rise enormously. Many of our low marshy seacoastal areas in the United States have been of this type. One of the most striking examples of what can be done is that of converting Miami Beach, Florida, from a mangrove swamp to a large area of fine estates and beautiful mansions. The engineer has seemingly been responsible for this, but the incidental control of the insect problem and the consequent control of malaria and yellow fever has been the secret to the choice of these areas for homes and the subsequent rise of these real estate values.

It would seem that those industries which are concerned with various metal products and their use in a commercial way are entirely removed from insect questions, but investigation shows that even these in some cases are affected. The clogging of mill machinery by silk-spinning caterpillars during their migration before pupation has already been mentioned. We have on record a few cases where even the iron horse of commerce has been halted in its rapid course because of insects swarming or of gregarious migrations. And now comes the lead cable borer of the Pacific coast which deliberately bores into lead cables containing electric wires short-circuiting these and causing the companies involved decided losses.

Undoubtedly the insect problems that come closest home to all of us are those concerned with health and sanitation. All foods are dangerous as sources of insect contamination since they may contain insect larvae which cause myasis in man or may contain disease organisms transmitted to these foods by insect vectors. Restaurants, hotels, food shops of all types, and even the home may be places where the insect problem is an important one to life and health. As a specific example, I might cite for you an experience of a few years ago when I was privileged incidentally to enter a dark, gloomy, artificially-lighted basement kitchen of a large restaurant in one of our eastern cities and found the cockroaches perfectly at home and crawling about in great numbers, leisurely walking in and out of the roast chickens lying upon the meat block, not to mention other articles of food which were constantly being contaminated and which would later be taken to the tables above in an attempt to satisfy waiting appetites. The entire kitchen presented the same appearance of extreme carelessness in regard to sanitation.

The household also contains pests that injure fabrics of all types from the carpets and rugs on the floor to the woolens which are stored away until the following season. These affect decidedly the home life of man. The physicians must treat diseases that are partially or entirely insect-borne such as typhoid, dysentery, enteritis, anthrax, malaria and yellow fevers.

I have mentioned several of the wide variety of industries or professions af-

fected by insect pests more or less directly in their relation to raw materials or finished products. If we consider those industries affected when we attempt to devise and use control measures for these pests, we must mention many others which we have not previously considered.

Probably the largest group of industries thus affected are the chemical companies which manufacture arsenicals of various types, lime and sulphur products, copper sulphate, fluorides and fluosilicates, plant products such as pyrethrum, derris, nicotine and their extracts, soaps, oils, both vegetable and petroleum, as well as acids and salts of various kinds which are used as chemical controls for many types of insects. Also the spraying and dusting machinery manufacturing concerns should be mentioned whose business is built entirely upon the presence of insects or other pests in sufficient abundance to cause economic damage.

More recently it has been necessary to manufacture special machinery like the aphid-dozer for the pea aphid, the stubble beater, corn-cutting machines and special types of cultivators for the corn borer, and attempts have been made to manufacture and use electrical machinery, complicated and expensive mechanisms in some cases for the control of stored products insects. The cold storage industry is now becoming a special device for insect control.

This brief résumé may bring to some who have not given it thoughtful consideration the importance of the insect problem as related to industry. In view of these problems more industrial companies are realizing their need of trained entomologists and there is a greater demand for men who are able to handle these problems. The insecticide concerns and oil companies are employing trained entomologists to fill research positions and carry on field experimentation. The canning factories and furniture dealers are also employing trained men for specific insect control duties. Super-heating and cold storage plants costing a hundred thousand dollars or more in many cases are being installed for problems of insect control alone. The economic entomologist to-day may find his work varying from the pure science, on the one hand, to the applied and strictly industrial phases, on the other. It can therefore be clearly seen how the applied phases of entomology and research along these lines have helped and are helping to solve many of the important problems of industry. Thus entomology is rendering a biological service through these applied phases which is not surpassed by other biological sciences.

FISHERY PRODUCTS IN THE ARTS AND INDUSTRIES[1]

By LEWIS RADCLIFFE
U. S. BUREAU OF FISHERIES

Our thoughts of fish and fisheries are usually in terms of food and sport. We are prone to forget that from prehistoric times to the present fishery products have served many other and varied uses. Amber, corals, pearls and shells of many kinds were used by ancient man for barter. Wampum, consisting of beads made from shells, was used by the North American Indians as money, ceremonial pledges and ornaments. The Egyptians and the Assyrians derived dyes from certain species of molluscs. The royal purple of the period of the Roman Empire was so gotten, factories being scattered throughout Italy and Greece. Sepia also was obtained from the ink sac of another mollusc. The teeth of porpoises and sharks, like wampum, have served as a medium of exchange in some of the islands of the Pacific.

Many products which at one period seemed highly essential in satisfying human needs have been replaced by more modern inventions and discoveries. With the development of the Argand burner in 1784 whale oil became the principal illuminant for homes, streets, lighthouses, etc. Formerly whalebone was extensively used in making ribs for umbrellas and parasols, in the manufacture of hoops in the dresses our grandmothers wore, and as corset stays in the days when our mothers were young. Shark skins as abrasives for polishing wood, ivory and the like have been replaced by emery and sandpapers. With the exception of choice pearls and corals, ambergris was at one time the highest priced product of the fisheries, selling for upwards of $640 per pound, the take from the intestine of a single whale selling for as high as $60,000. The principal use was as a fixative in the preparation of fine perfumes. As synthetic substances have become available at a fraction of the cost, the use of ambergris in recent years has greatly decreased, until it has sold as low as $128 per pound.

While many fishery products have dropped within the limbo of the forgotten past, the number of such products catering to our needs and vanity to-day are greater than at any time in the history of the world. Figuratively speaking, the modern flapper might dive into the sea and emerge completely clothed and adorned with aquatic products, such as to be the envy of any mermaid of the briny deep. She will be wearing a dress of artificial silk made from the shells of crabs, lobsters, or other crustaceans; a fur coat of otter, sealskin or beaver, with mink or muskrat trimmings; shoes of shark-skin and mussel shell buckles adorn her feet; the buttons on her dress are of pearl derived from fresh-water mussels and those on the coat of true pearl, abalone or artificial pearl. She wears a string of natural pearls on special occasions, and a duplicate set of imitation pearls for ordinary use. Coral earrings and a tortoise shell comb complete her outfit. In her alligator leather handbag she carries a cake of soap made from fish oil; cold cream from whale oil; a sponge; a bottle of perfume with ambergris as the fixative, a hand-lotion made from sea-

[1] One of the Smithsonian series of radio talks arranged by Mr. Austin H. Clark and given from Station WRC, Washington.

LA PAZ, LOWER CALIFORNIA
TAKEN IN 1889.

A MUSSEL BARGE
EQUIPPED WITH CROW-FOOT HOOKS; VEVAY, INDIANA, 1913.

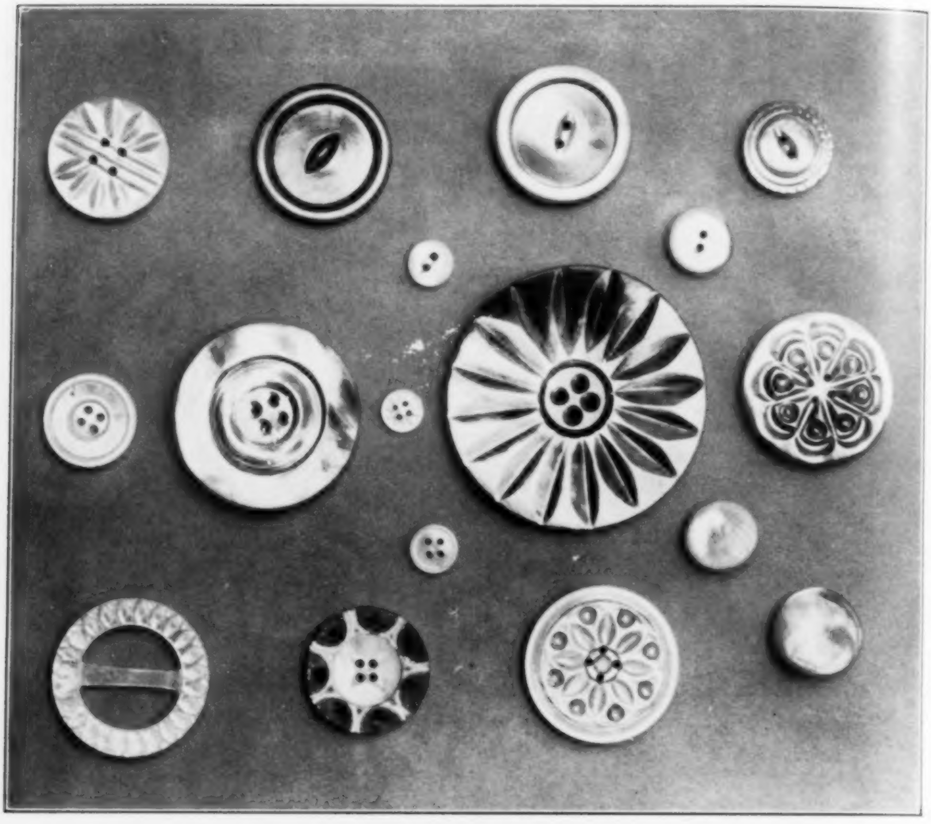
moss, and gloves of cod skin. On her way home she views a photogravure which was covered with fish glue before etching and purchases a beaver hat adorned with an aigrette made from whalebone; a toilet set trimmed with artificial pearl made from fish-scale essence; am amber pipe for her husband; a bottle of cod-liver oil and a package of agar agar for gelatin for the youngsters, and a piece of cuttle-fish-bone for the canary.

Pearls have been described as "Heaven-born and cradled in the deep blue sea; it is the purest of gems and the most precious."

Pearls were the earliest gems known to prehistoric man and throughout the centuries have continued to be prized most highly. So highly valued are they that it is most natural that man should strive to grow them and to produce imitations of true pearls. As a result we have three classes of pearls: Genuine pearls, *i.e.*, those produced in nature by pearl-bearing molluscs; artificial or culture pearls, *i.e.*, those produced by molluscs, as a result of artificial stimulation by man, such as the insertion of foreign objects into the mantle of the mollusc; and imitation pearls, *i.e.*, products made to resemble pearls.

In North America genuine pearls are found in the pearl oysters of the Gulf of California; the abalone of California and Lower California; the queen-conch of the Gulf of Mexico; and the fresh-water mussels of the Mississippi River system. These fisheries are now relatively unimportant. The production of culture pearls is confined to Japan, where the annual output has been valued at $600,000.

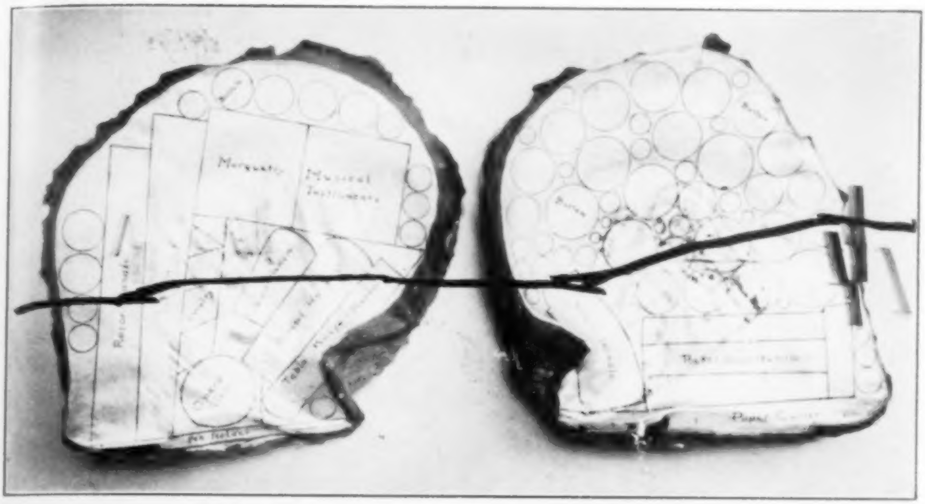
About 1656 Jaquin, a French rosary maker, noted that the water in which a small minnow had been washed contained a highly lustrous substance, which when concentrated closely resembled



SAMPLES OF BUTTONS MADE FROM THE BLACK MOTHER-OF-PEARL SHELL

pearl. Applying it to small globes of alabaster, Jaquin produced for the first time excellent imitations of pearls. The crystals which give this lustrous effect are found on the scales of fishes. From the seventeenth century the European minnow which Jaquin used continued to be the chief source of supply of pearl essence or fish-scale essence, and became the basis for a very large industry. During the World War, the European supply was cut off and research with other fishes, coupled with improved methods, resulted in the developing of new sources of supply in this country and the building up of a new and important industry. This new source of supply is obtained chiefly from the sea herring of New England. At the present time, two million pounds of fish scales are used annually, for which our fishermen receive about $140,000. In addition to the manufacture of imitation pearls, the essence is employed in the manufacture of imitation mother-of-pearl celluloid products, which, in turn, are used on backs of brushes, hand-mirrors and other toilet articles, for umbrella handles, buttons, etc. In a decade this domestic production of pearl essence has become sufficiently large to attract foreign buyers, and the manufactured products now are to be found even in the "Five and Ten" stores.

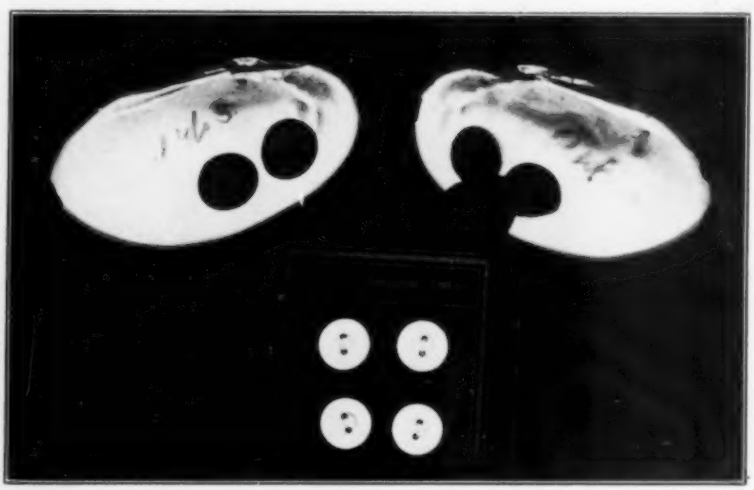
Formerly the fresh-water mussel fishery was prosecuted primarily for the



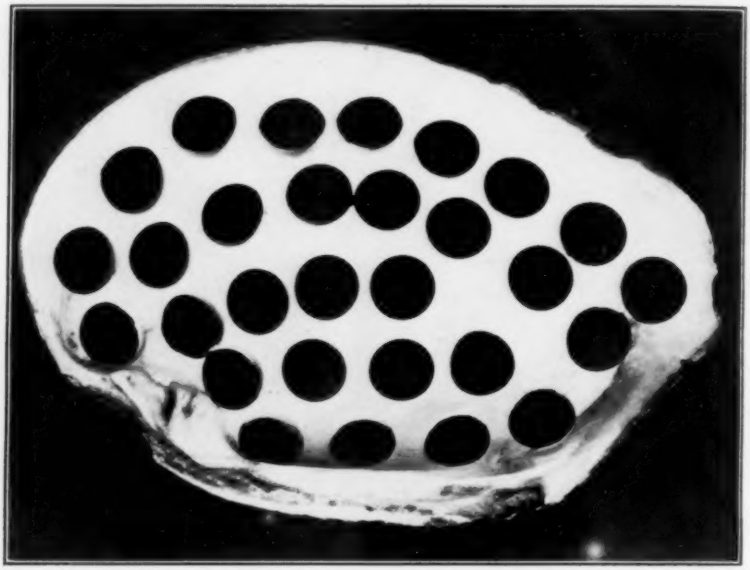
A BLACK MOTHER-OF-PEARL SHELL
SHOWING HOW IT IS CUT UP FOR THE MANUFACTURE OF VARIOUS OBJECTS.

taking of pearls. To-day it is the chief source of pearl buttons, producing over three billion buttons per year or twenty-seven buttons for every inhabitant of the United States. Add to this five additional pearl buttons per capita of domestic manufacture from marine shells.

In 1621, Squanto, the friendly Indian, gave corn to the white settlers of Plymouth and taught them the use of menhaden as a fertilizer. After three hundred years, huge quantities of menhaden are still used for manufacture into scrap for fertilizer, or fish meal, as an animal feed, and the oil extracted for use in paints, soap-making, in the manufacture



MUSSELS REARED IN PONDS AND BUTTONS CUT FROM THE SHELLS
TWO YEARS FROM DATE OF INFECTION; FAIRPORT, IOWA, DECEMBER, 1915.

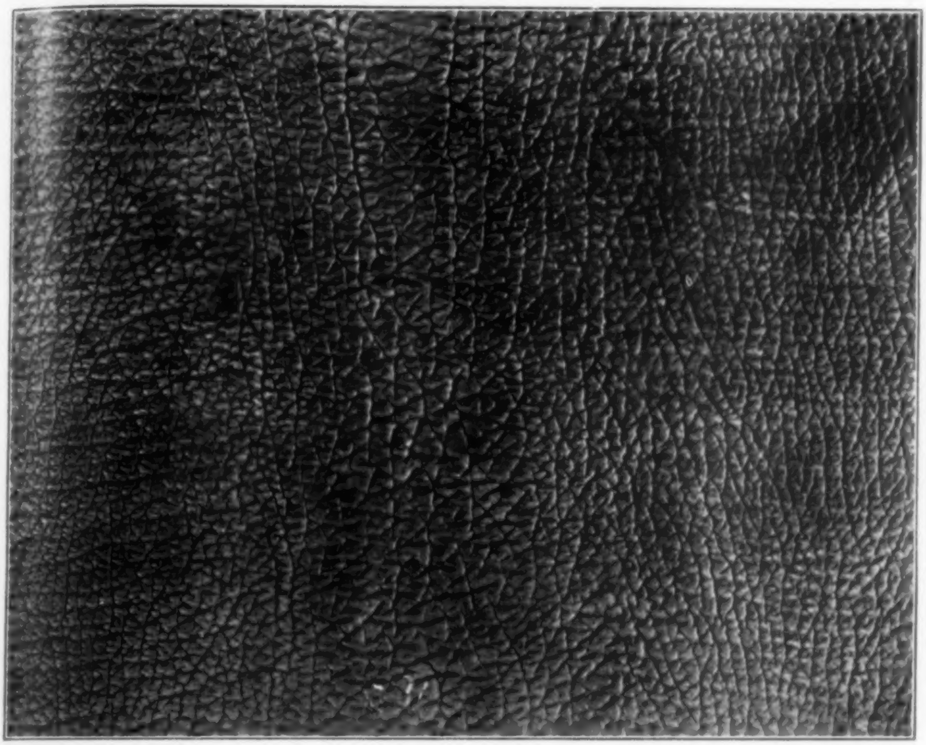


A "WASH-BOARD" SHELL

(*Quadrula heros*) $4\frac{5}{8}$ BY $6\frac{1}{4}$ INCHES; FIVE DOZEN BUTTONS WERE CUT FROM THE ENTIRE SHELL.

WORN SHOES OF SHARK AND CALF LEATHER

THE CALF LEATHER SHOES ARE SHOWN TO BE SCUFFED, WHILE THOSE MADE OF SHARK LEATHER HAVE NOT BEEN MATERIALLY INJURED BY ABRASION.



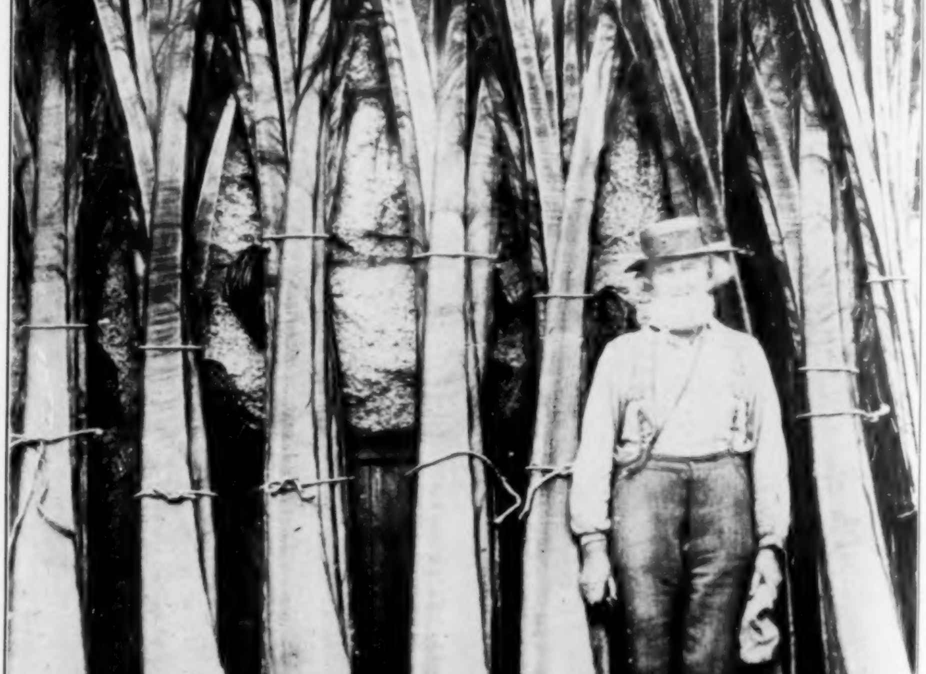
SHARK LEATHER
SHOWING THE CHARACTERISTIC GRAIN PATTERN OBTAINABLE.

and stuffing of leather, and for many other purposes. We now produce about 13,000,000 gallons of fish oil valued at $6,500,000 and 120,000 tons of fish meal and scrap, valued at $4,600,000 annually.

Formerly, the oyster packer was confronted with providing some means for disposing of the ever-growing heap of shells. To-day the demand is greater than the fishery can supply and beds of shells of another age are being dredged and carried to the grinders for the making of poultry grit and lime. We produce about 300,000 tons of these products, valued at $2,400,000 yearly.

Agar agar, the dried gelatinous extract of certain seaweeds, is highly important in hospitals and bacteriological laboratories, where it is used as a base for culture media in the study of bacteria and as a valuable dressing for certain types of wounds. In times of war, this country fortunately need not be without an available supply of agar agar, as there is at least one company producing a domestic product of good quality.

From time immemorial the pursuit of whales has been a fascinating and rigorous business. Formerly, only the oil was saved and species like the sperm-whale were most sought for. To-day every scrap of the whale is used—oil, whalebone and scrap or meal being the more important products. The introduction of the harpoon gun and the use of fast boats have added materially to the toll taken of whales yearly. More recently huge floating factories or ships have been



SLABS OF WHALEBONE
IN A WAREHOUSE AT NEW BEDFORD, MASSACHUSETTS, 1902.

SEAWEED ISINGLASS AND SEAWEED GLUE
FROM JAPAN.

built. Some of these are provided with arrangements at the bow, stern or sides of the vessel for hauling these huge mammals aboard for cutting up and reduction, thus obviating the need for shore stations. The fishery is prosecuted with such energy that from ten to twenty thousand whales are being killed annually for reduction purposes, and unless some form of international control is exercised, the supply will soon be commercially exhausted.

Sharks—the wolves of the sea—are now being converted into useful products. Excellent leathers are being made from the hides. The distinctive exterior when tanned makes the leather especially valuable for bags, pocket books and novelty articles, as well as for shoes. The untanned hides of some species are used as abrasives and for sword hilts and grips, as well as nose grips for eyeglasses. Shark fins are an oriental delicacy; oil is extracted from the livers, and the flesh used for fertilizer or feeding purposes.

The skins of many aquatic animals have been used for leather or novelty purposes. Sturgeon, gar-fish, wolf-fish, cod, cusk, water-snakes, frogs and many other forms have been so used. Eel skins have been tanned for book-binding, in making whips, suspenders, etc., or dried and oiled for use as a substitute for glass in windows. Many primitive people use the skins of salmon and cod for making garments, bags and sacks. Bags of alligator hides are in much demand. Hides of seal, sea-lion and walrus are also tanned into leather. The latter is especially useful to silversmiths, gun manufacturers, etc., for removing mars and scratches and for polishing fine metal surfaces. Some of my radio fans may even remember the round leather shoestrings of a former day which were made

from porpoise hides. Fish skins, such as cod and haddock, are used in the manufacture of fish glue. Fish sounds or air-bladders are extensively used in the manufacture of isinglass, for clarifying beverages, in adhesives, in sizings to impart a luster and stiffness to linens and silks.

The chief source of supply of the highly prized fur-seals is the Pribilof Islands. Under the wise administration of the Department of Commerce, the herd of fur-seals breeding on the Pribilof Islands has been increased from 140,000 to approximately 800,000 animals in fifteen years, and the annual killings now number over 20,000 animals. As the herds of these animals in other parts of the globe are very small indeed in comparison, were it not for the careful supervision exercised by the Federal Government over the Pribilof Islands herd, fur-seal coats would soon become a far greater luxury than they are to-day. With the upbuilding of this herd, it is hoped to reduce the price of sealskin coats within the reach of many more of our people.

In passing, mention may be made of the recovery of iodine and potassium salts from sea weeds; and common salt and other chlorides from sea water by solar evaporation. In California this is an important industry. Sea water also contains small quantities of gold, silver and radium. Unscrupulous persons have taken advantage of this fact and have sold stock in fake schemes for extracting these valuable elements. The cost of extraction is much greater than the value of the gold recovered, as many investors have found to their sorrow. The history of the products of the sea is replete with fascinating stories—the history of the coral industry, the sponge and pearl fisheries, the seaweed industries of Japan and many others.

STATE GEOLOGICAL SURVEYS

By Dr. HENRY B. KUMMEL

STATE GEOLOGIST OF NEW JERSEY

Historical Summary

It is nearly one hundred years since the Reverend Edward Hitchcock, of Amherst College, was appointed in 1830 to make a geological survey of Massachusetts, the first of many similar undertakings. In recommending this survey to the legislature, the governor emphasized the fact that by it "much knowledge of the natural history of the country would thus be gained, and especially the presence of valuable ores, with the location and extent of quarries, and of coal and lime formations—objects of inquiry so essential to internal improvements, and the advancement of prosperity—would be discovered and the possession and advantage of them would be given to the public."

Two points in this recommendation and in the subsequent legislation are significant. First, the emphasis is placed on a natural history survey as distinct from a strictly geological survey, and second, the avowed intention of fostering the economic development of the state. The complete report issued in 1833 contained sections dealing with economic, topographic and theoretic phases of geology, as well as lists of plants and animals. It was, therefore, of wider scope than the letter of the governor's recommendations or the legislature's enactment. In these respects this first state survey has on the whole been followed by most of its successors.

As Merrill has pointed out in his admirable history of state surveys the succeeding decade saw them established in eighteen states. So far as I have been able to examine the laws under which they were started, the general plan of the Massachusetts survey was followed; emphasis was placed on the economic advantages which it was expected would result; botanical and zoological studies were included, although the major emphasis was placed on geology, but in their execution they added much to the sum of geologic knowledge in fields other than utilitarian.

In all these early surveys, as indeed in many of the later ones, it was anticipated that the work could be completely accomplished in a few years, generally in three or four. Appropriations were made on that basis and final reports were published. Indeed, it is doubtful if, then or for many years after, it would have been possible to have secured the passage of legislation establishing a permanent or continuing bureau. Even in those states whose existing surveys have had the longest records, as New York, New Jersey and Alabama, the present organization was preceded by one or more earlier surveys, or there were lean years when all state appropriations were withheld, and the work was conserved solely by the personal devotion and interest of the state geologist. In New Jersey the present survey was authorized for a period of four years only; then for five years more, and so for succeeding periods until the adoption of an annual appropriation bill for all state expenditures removed the necessity of special enactments and established the survey as a continuing bureau.

Merrill lists thirty-six states in which surveys had been established previous to 1900, with total expenditures of more

than five and a half million dollars, exclusive of a very large but uncomputed sum spent on publication. In 1911 the number of states with surveys, past and present, had increased to forty-four, Idaho, Montana, New Mexico and Utah being the only laggards. It is my impression that they are still in that class.

It is safe to say that the total expenditures by state surveys, during the past century, including cost of publication of reports, which is commonly not included in the direct appropriations, has been in excess of $10,000,000. Large as this sum seems in the aggregate, it is only a little more than $100,000 per year, if distributed over the century. From the standpoint of time, area and natural wealth, it is pitifully small. The profits of a single year in many an industry has more than once exceeded the entire cost of the survey to which it has owed so much.

My excuse for this brief summary of the history of geological surveys is not that it contributes anything new, but that it may form a background to what follows.

Public Expectation

Of all the factors which have to a greater or less extent guided and controlled the work of geologic surveys, public sentiment or public expectations have unquestionably been foremost. The survey which ran counter to public demand, as voiced by legislature or governing officials, came to an untimely death, usually from financial starvation.

Perusal of the various laws demonstrates that the primary purpose in the minds of legislators was almost without exception utilitarian, a study of the natural resources with a view to their (a) exploration, and (b) their exploitation.

Investigations for the discovery of new facts unless they have a utilitarian aspect were not contemplated. Studies primarily for the purpose of writing the history of the earth were not considered. Some of the early surveys and some of the later ones also went to pieces on the rocks of too much pure paleontology, too elaborate plans or too much topography, the value of which was not apparent. Surveys were not urged because there was any particular interest in geologic science as the key which would unlock the book on whose pages was recorded the history of our globe. Indeed, when the earlier surveys were voted, the prevalent view was that that history was adequately given in the first chapter of Genesis, a view which seems not wholly to have disappeared even at the present day. They were established because they would "create taxable values," "lead to the development of local resources," "furnish land owners reliable information regarding the value of their lands, so they would not part with them to better informed strangers at prices far below their real value."

Although their educational value, the resulting gain in the sum of human knowledge, the answer these studies might make to man's "how" and "why," were not altogether lost sight of, they were rarely if ever emphasized.

This being the foundation, therefore, upon which nearly every survey started, it has been inevitable that the economic or utilitarian phases have always been and in most states still continue to be stressed.

This does not mean, however, that the state surveys have not added largely to our knowledge of the broader problems of geology. No geologist can ever be unmindful of the debt the science owes to James Hall and the New York Survey, whose purely paleontologic studies established the New York series as the standard Paleozoic section. While New York has perhaps been the leader in this field, other states have made notable contributions. Much of this has been

the result of a wise and broad comprehension of the real basis on which economic reports must rest. It is as important to determine the location of mineral deposits geologically as it is geographically. This involves more or less detailed studies in stratigraphy, the proper classification of geologic formations, possibly studies in microscopic petrography and in paleontology. Correct theories of the origin of mineral deposits are often essential to their economic exploitation; so too is an intimate knowledge of the geologic structure, the successive stages in its development, the proper sequence of deposition, folding and faulting. Again, the value of many mineral deposits depends in a large measure upon secondary changes—leaching, concentration, replacement, etc., factors unknown in large measure to the earlier geologists, but later developed by many workers, some of them upon state surveys. Solving of these problems often leads to fields at first sight far removed from utilitarian problems, but they can not be wholly neglected.

From all this it follows that while the state survey must always be primarily along utilitarian lines, this does not mean that its studies may not embrace a wide field and that the by-products of its labors may not contribute largely to the advancement of science. Moreover, it must always be borne in mind that there is a small but slowly increasing number of our clientele who are interested in the geologic history of the earth not as a means of exploiting its resources, but as history. More and more our public school teachers are called upon to present to their scholars the fundamental principles of physical geography.

It can fairly be a part of the duty of the state survey to point out how these principles can be illustrated locally; to make clear the extent to which the life of its people is guided and controlled by the geologic structure of the state. Indeed, the more clearly this can be done in all reports, the more assured the survey will be of support. Too often in the past the work of the geologist in whatever field has seemed to have no connection whatever with the ordinary everyday life of the people. The successful head of a state survey is he who can best bring this home to his citizens, without departing from the high standard of scientific investigation.

Personality

The second of the factors which have controlled and directed the work of state surveys has been the personality of the geologist in charge. By this I mean those qualities of head and heart which have made him not only an able investigator, a discriminating observer and a sound reasoner, but those other qualities, which have enabled him to inspire confidence, to judge rightly the demands of his clients, to persuade doubting Thomases in the legislature or when necessary to beat down all opposition by the very force of his unquenchable spirit and devotion to his work; in short, those qualities which have enabled him to guide his ship through stormy seas, avoiding the barren rocks of recorded but uncorrelated observations on the one hand and the treacherous sands of too much pure science on the other.

It is interesting to note in this connection that investigations which in one decade brought ruin to a survey have in later years been carried through with approval when the organization was more firmly established in public confidence, or when there was a wider appreciation of the value of that specific work. A single instance may be given. The Kitchell Survey was established in New Jersey in 1854; it died of financial starvation in 1856, after spending $35,000, a very considerable part of it for triangulation and a topographic survey—a project which, however admirable in

itself, was somewhat ahead of its time. When the work was resumed in 1864 under Dr. George H. Cook, it was not until about 1880 that a topographic map was attempted and then only because further progress in geologic work had been halted for lack of an adequate base map. By that time, however, the public had been educated to the importance of an accurate map, and the completion of the topographic survey and its publication under state auspices did more to establish the geological department on a permanent basis than any other piece of work it has ever undertaken.

Every one who is at all acquainted with the work of Hall in New York, Cook in New Jersey, W. B. Clark in Maryland, White in West Virginia, Smith in Alabama, Orton in Ohio, Chamberlin in Wisconsin, to mention only a few of the state geologists who guided their organizations to firm foundations as established bureaus, or brought their more limited surveys to a well-rounded completion in accord with legislative mandate, will recognize how important has been the personality of the state geologist, in determining the scope and character of the work.

Requirements as to Publication

An annual report has been a very common requirement, a practice that has some good and some bad elements. It has required the geologist to render a frequent accounting to his clients. It has given him an opportunity to get before them some of the results of his work. The far-seeing have used it as an opportunity to win support for the work; others have overlooked its possibilities in this respect. In many states it grew in size, and in complexity of its contents, until it frequently lost its value in this respect, particularly when its publication became too greatly delayed. Too often it became the vehicle of hastily prepared "reports of progress" with conclusions which not infrequently had to be revised. Successive papers of this character may be interesting as a study in the development of an author's views, but they are a sad stumbling block to the student trying to reach the roots of a problem.

Fortunately in most surveys where this requirement still exists the annual report has now become a mere administrative report, which in most instances would never be missed if never written, and the scientific studies are published as bulletins or more elaborate reports. It is no exaggeration to say that the style, subject-matter, and time of publication of reports have been most important factors in the life or death of state surveys.

Politics

As we read the history of some state surveys, the conclusion can not be escaped that sometimes in some states they have felt the withering hand of partisan politics. Indiana for years elected its state geologist along with its governor and other political officials. Naturally the reports of that state did not deserve and did not command high standing, although this does not mean that some of the men who held the position were not good geologists. When the state in successive elections was carried by the same party, there was a certain degree of continuity in office and unity of investigation, but it was almost inevitable that the incumbent performed his tasks with one eye on the rocks and the other on his political fences. On the whole, however, so far as I know, the political spoilsman in most states has kept his hands off the surveys, perhaps as much from the fact that they had comparatively little money to disburse as for any other reason.

Recent Developments

Of recent years three movements which are more or less widespread have

affected the administration of all state scientific bureaus. These are civil service regulations, the budget system and consolidation of departments.

Civil Service Regulations

In many states civil service rules control the appointment of both clerical and technical employees. They vary in different states and, therefore, no statement can be made which will be equally applicable to all localities. I venture to say, however, that wherever the appointing officer is not subject to political pressure, and desires only ability and efficiency in his staff every civil service rule which restricts him in his freedom of appointment and regulation of salary is an impediment and not a help in administration.

In New Jersey it is invariably the case that the department must find its own technical men, and in this the Civil Service Commission is no help; it has no eligible list for this type of employee, but after the right man is found and given a temporary appointment, he is subject to a competitive examination, and it is often months after he begins work before a permanent appointment can be made. At the best there is at least the necessity of conferences with a department with no particular knowledge of the type of employee needed; at the worst there is delay, lost motion and one more administrative detail for the scientific head to bother about.

Budget

The growing adoption of the budget system in many states has complicated the accounting system, increased the administrative cost and introduced a decided element of inflexibility in appropriations. This is worse in some states than in others. Where it goes so far as to fix a year or two years in advance all expenditures in great detail, it becomes increasingly difficult to carry on the work wisely and economically. There may be a surplus for salaries, and a shortage for field expenses; too much for typewriter ribbons, which are office supplies; not enough for machines on which to use them—the latter being office equipment. If there be no machinery for shifting sums during the year, the work is often hampered because of inability to move it in certain directions. The funds of the Department of Conservation and Development of New Jersey, of which the Geological Survey is a part, are appropriated under thirty different heads, some of which are for the specified purpose only, and can not be shifted. In other instances transfers can be made with the consent of the fiscal officers of the state. Fortunately entrances to some of these stalls look much alike, and in times of emergency some items have been known to get into a stall with a full manger when their own was empty. Practically the entire time of two clerks is needed in the accounting division to keep track of the expenditure of $200,000 annually—with less red tape one would suffice.

Consolidations

In some states in recent years various bureaus more or less closely related in function have been consolidated into large departments. Illinois, Indiana, Pennsylvania, New Jersey and New York may be cited as examples. Geological surveys have been involved in many of these. In Pennsylvania the survey is, or was, until recently, a part of the Department of Forests and Waters; in Indiana and New Jersey, a part of the Department of Conservation and Development; in New York a part of the State Museum, which in turn is a part of the University of the State of New York; in Illinois it is in the Department of Registration and Education.

The degree to which the geological survey has preserved its separate identity in the consolidations varies in nearly every case. In Illinois it receives its own appropriations. In New Jersey it is one of the divisions of the department under the general board of control to which the appropriations are made, and while at present the state geologist is also director of the entire department, he may at four-year intervals be replaced as director by the chief of one of the other divisions.

Whether these consolidations have been to the advantage or detriment of geologic work depends, I imagine, in part upon the specific form of organization and in part on the personnel.

If they have resulted in placing the survey under the control of a chief, technical or otherwise, who is not in sympathy with this work, the effect may be unfortunate, particularly if appropriations are made to the department as a whole. In New Jersey the chief detriment has been the loading up of the geologist with so much work, administrative and otherwise, that he has not of recent years been able to give the time and attention to geologic work which he would like.

This, however, is not a condition peculiar to New Jersey or to geological surveys. With the increase in appropriations and the growth of all scientific bureaus, more and more have administrative duties encroached on the time and strength of the technical and scientific heads. Much as this is to be regretted, it is perhaps preferable to having them administered by those who are untrained in scientific methods of work and who may be too strongly impressed with the stop-watch methods of the efficiency engineer.

Summary

From this hasty review and somewhat sketchy treatment the following conclusions seem clear:

State surveys are established and maintained primarily because of the belief that their investigations will promote the development and wise use of the state's resources, particularly the mineral resources, using the term in its widest sense.

The wise administrator will never lose sight of this fact, but will nevertheless recognize that this end will be best attained when not too narrowly limited. Many a study undertaken with no economic end in view has yielded rich returns in unexpected directions. The general educational aspect of the survey's studies can not afford to be neglected, for by them much support may be gained. In one way or another the value of the survey's work must be sold to the public through the press, by public addresses and by preliminary bulletins on topics of immediate interest.

In the earlier days of a survey when there is much to do and many resources to investigate, the work must of necessity be much more largely "practical" than "theoretical," applying these words in their commonly accepted, although somewhat erroneous usage. Later, greater refinements can be undertaken and broader problems can be considered. In no two states are conditions identical, and in some degree every survey must be a law unto itself. But in every case the goal should be an accurate and scientific study of and report on the natural resources, their conservation and development and a true interpretation of the geologic history of the state.

COMMON FOOD FALLACIES

By T. SWANN HARDING

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In Plato's "Republic" Socrates is made to speak as follows—"There are charming people who are always doctoring and increasing and complicating their disorders, fancying they will be cured by some nostrum somebody advises them to try. . . . They have a charming way of going on and the charming thing is that they deem him their worst enemy who tells them the truth, which is simply that, unless they give up eating and drinking and lusting and sleeping, neither drug nor cautery nor spell nor amulet nor anything will be of any avail." Undoubtedly something similar may be found in the sacred books of the East which will, on close examination, usually be found to have antedated all the scientific lore of the Greeks by thousands of years; but it is the custom to imagine that science began with Greece and we shall here be conventional.

Who then but the physician should advise the patient in such cases? How competent is the average physician to advise wisely on nutrition at a time when every newspaper and magazine has space to give to the most utterly misbegotten diet fads and fancies the disordered brain of a maniac could invent?

Let us listen momentarily to Eric Pritchard, medical director of the Infants' Hospital, London. He wrote on "Common Mistakes in the Artificial Feeding of Infants" in the *British Medical Journal*, September 25, 1926. He remarked, for instance, that most physicians still adhere to the exploded view that fuel is to the engine precisely what food is to the body and that caloric value alone needs to be considered. In the light of the newer knowledge of nutrition this is gross error. He again notes that many infants are still fed whole or unmodified dry cow's milk in spite of the fact that this causes them to form the habit of over-secreting hydrochloric acid in their stomachs, and that they either die in the attempt to produce enough acid to digest casein or else suffer at a later date from stomach acidity due to their successful adaptability in earlier life.

Scurvy is a disease now well understood. Regarding this, Pritchard says: "We know, for instance, that the symptoms of scurvy in infants do not manifest themselves for some three or four months after the commencement of a vitamin-free diet. This is the reason for the astonishing practice, which is so prevalent in this country, of delaying the administration of anti-scorbutics until after the third month of life. The argument is so plausible; infants under three months of age do not have scurvy; therefore they do not require antiscorbutics. If there is one period more than another when infants, and especially premature infants, stand in need of this and other accessory factors in their diet, it is during the first three months of life." The gross and wide-spread error of the physician here is patent to any intelligent reader.

Consider a patient who has fallen ill and who goes to an orthodox practitioner. We shall assume that the doctor diagnoses hypertension or high blood-pressure. How will the physician then proceed? Nine times out of ten he will advise the patient on diet and in doing so will demonstrate that the famous Brit-

ish physician, Horder, was not very far wrong when he declared that the average practitioner's knowledge of nutrition in disease, regardless of the nature of the disease, is usually summed up in two words—"Drink milk!"

The physician may advise any of the following things. He may say drink certified raw milk. But just why? As a matter of fact pasteurized milk is not only demonstrably safer but it actually may often be a better food because it is likely to contain more vitamins than raw milk! This seems paradoxical, but cows producing raw milk are not usually permitted to go to pasture, and it has been demonstrated that green pasturage and exposure to sunlight greatly increase the vitamin content of a cow's milk, while a cow which is fed dried rations and kept exclusively in its stall, gives milk of very low vitamin content.

The physician will very likely say eat a great deal of coarse food—whole wheat, bran, fruit pulp, agar—anything to keep the bowels functioning freely. That is a good part truth. Bulk does have its usefulness in imparting proper consistency to the contents of the large intestine, but the coarse food theory is constantly overemphasized. For one thing coarse food particles close rather than open the pyloric sphincter (exit to the bowel) when they bound against it from the inside of the stomach; they thus do actually delay the passage of the chyle from the stomach to the small intestine, thus slowing down the digestive process. (Stiles—*Nutritional Physiology,* Edition 3. See also Alvarez—*J. Amer. Med. Soc.,* August 6, 1927.)

As a matter of fact physicians usually get much exercised over constipation in their high blood-pressure patients. Some actually advise them to take a tea-spoon of salts after every meal! Yet it has been shown that men are more disposed to high blood-pressure than women, while women are uniformly more constipated. It has even been shown that constipation has no effect on blood-pressure in men and that it actually tends slightly to lower the blood-pressure in women! (Alvarez, *Archives of Internal Medicine,* 38, 158, and *Physiological Reviews,* July, 1924, 352; MacWilliam, *Physiological Reviews,* July, 1925.)

Physicians will usually say avoid salt in hypertension. Yet salt is very necessary to the human economy. For digestion to function properly there must be chlorides in the blood and a large portion of our body chlorides reaches us as common salt. Even people with high blood-pressure should have good digestion. Furthermore, experiments have shown that the amount of salt eaten, even when varied within relatively large limits, does not affect the blood-pressure one way or the other. (MacWilliam, *Physiological Reviews,* July, 1925.)

Another common warning to such patients is "Cut down on meat." But just what has the physician in mind? In so many cases he, being also human, bespeaks a common convention without thought of scientific background. Sometimes when he rules out meat he has his mind vaguely on the patient's kidneys. But high blood-pressure has never been demonstrated to be a factor in the etiology of Bright's disease. Focal infection is as likely a cause as any, although even that is debatable and the etiology of nephritis remains a baffling problem. (See "Why Infection?" Nicholas Kopeloff.)

Furthermore, most abnormally high protein diets continued throughout the major fraction of the lives of experimental animals have not been definitely shown to cause kidney lesions, or anything else save a slight hypertrophy, an hypertrophy composed of normal, healthy, functioning kidney tissue, having no pathological significance, and soon disappearing after the reinstatement of a normal diet. Human experi-

ence also shows that normal amounts of meat can not be held to cause kidney trouble. They do not even cause hypertrophy. It is very doubtful whether they cause any deleterious effects. (Osborne, Mendel, Park, Winternitz, *Journal of Biological Chemistry,* 1927, LXXI, 317–50; Jackson, J. B. C., 1926, LXVII, 101; Osborne and Mendel, *Proceedings* National Academy of Science, 1921, VII, 157; McCollum, Simmonds, Parsons, J. B. C., 1921, XLVII, 126; Reader and Drummond, *American Journal of Physiology,* 1925, LIX, 472; Sherman, "Chemistry of Foods and Nutrition.") Finally it has been shown that the blood-presure is entirely unaffected by very considerable differences in the protein intake. (Alvarez, *Physiological Reviews,* July, 1924.) See also J. J. MacWilliams, *Physiological Reviews,* July, 1925, 303–335.

The physician advises a little tonic and he may even prescribe iron and syrup of hypophosphites! Why? The normal diet contains ample iron, an element the body always uses economically anyway. (Sherman, *op. cit.*) Syrup of hypophosphites has been proved to be inert physiologically; it is not a food; it has no therapeutic value and its use is simply an affront to sound therapy. (Marriott, *Journal of the American Medical Association,* 1916, LXVI, 486.)

The physician may next say, "Your urine shows a very high uric acid. That comes from eating too much meat. You must curtail your use of red meats." One patient remarked abstinence from meat for a period of two years prior to this examination. The physician hoisted an eyebrow, smiled quizzically, remarked that the analysis must be in error—which it was of course—and then gave the patient the only bit of rational advice in his arsenal. He said, avoid emotional excitement. And emotional excitement affects blood-pressure more rapidly and more powerfully than any known factor. (MacWilliam, Alvarez, *Physiological Reviews.*) The lecture on nutrition is ended; the patient is dismissed.

This indictment seems severe and perhaps based upon insufficient data. But it must be reflected that dozens of physicians voice these ideas and that such fallacies are held as fact by an important group of orthodox medical men. Physicians are not to be denounced as wilfully ignorant; that would be mere venom. What is needed and what most physicians want is medicine practiced scientifically and in harmony with the latest advances in physiology and in biological chemistry. This will require an effort on the part of laboratory investigators to acquaint the physician quickly with their assured findings as well as an alert curiosity on the part of the physician to inform himself of advances in laboratory work and to appreciate their fundamental importance.

When The American College of Surgeons met in Washington, D. C., in early 1927 there was a public health meeting in the auditorium of the District Medical Association. There were accommodations for half the people who came. The surgeons erroneously assumed that the entertainment provided by an East Indian Swami, who was then performing locally, would cut the attendance to the vanishing point. At the public meeting a half dozen of America's most noted surgeons addressed themselves to different aspects of one subject, "Longevity." Not a single speaker emphasized the importance of proper nutrition! They said, have an annual medical examination; go to an expensive hospital and bankrupt yourself on the slightest provocation; exercise more than is good for you; have offending organs ruthlessly excised; choose sturdy ancestors—but they one and all ignored the most important factor in preventive medicine and longevity, how to eat.

When Andrew Balfour, C.B., C.M.G., M.D. Edin., director of the London School of Hygiene and Tropical Medicine, addressed The Scientific Medical Conference at the University of Rochester, New York, on October 26, 1926, he took as his subject, "Through the Maze of Medicine." He then outlined various aspects of a more ideal medical education. He mentioned nutrition just once, and that was to say that medical students should be taught the rôle of vitamins in warding off deficiency diseases.

In other words, physicians too frequently ignore nutrition. They too frequently discount laboratory investigations as poppycock. Yet hundreds of diet fanatics pander to the public desire for knowledge by propagating all sorts of unscientific fake diets. We have just heard the dicta of a complex of numerous orthodox physicians in the presence of a specific symptom complex, or syndrome. .Indeed some individual physicians will advise nearly every item in the composite list. Such physicians really have little more to recommend them than quacks. For instance, there actually is in Washington a reputable stomach specialist who holds that prunes should not be eaten because they "rot the intestines!" He has probably learned that prunes, like a few other fruits, generate benzoic acid in the organism. But the body is amply provided with apparatus to throw off excess benzoic acid; it can not rot the bowels. But let us analyze a few more ridiculous food fallacies garnered from various physicians and non-medical *soi-disant* nutrition experts.

Our presumption is not that the nutritional investigator knows everything; indeed the fragmentary character of his knowledge should be contrasted with the dogmatic self-assurance of the quack. But he has established certain fundamentals and these the physician often ignores as negligently as the quack.

A clinical analysis showed that a certain patient had gastric hyper-acidity—too much stomach acid. A practicing physician advised that patient never to eat an acid fruit—lemon, lime, orange, grape-fruit. This means that there are actually some physicians unaware of the well-established fact that these acid fruits in the end contribute alkali to the organism. Furthermore, such organic fruit acids are so slightly ionized, that is they are such weak acids, that their contribution to the stomach acid—which may normally run as high as one half of one per cent. of the strong, mineral acid, hydrochloric—can not be other than negligible.

This patient was advised by two physicians to take sodium bicarbonate regularly. Certain authorities (Stiles, *op. cit.*) hold that while sodium bicarbonate does initially reduce stomach acidity, there is an almost immediate rise thereafter which over-compensates and makes the stomach more acid than it was at first. (Crohn, *Journal of the American Medical Association*, 1918, 155, 801.) Other authorities deny this but hold that the stomach may, in pathological conditions, empty with abnormal rapidity and that as soon as it does so a rapid acid secretion takes the place of the ejected bicarbonate. (*Bulletin*, Johns Hopkins Hospital, 1927, Keefer and Bloomfield.) In short, the problem is far from settled and the use of bicarbonate here is purely empiric.

The body is always making automatic and usually successful efforts to adjust itself to the variations in the food we give it towards the end of retaining its internal integrity as much unaltered as possible. For instance, the blood, gastric juice and intestinal juices of the same individual have the same salt content as is evidenced by the fact that they have the same freezing point.

This condition must be maintained. Now it has long been known that certain

types of plain dyspepsia yield as readily to doses of hydrochloric acid as they do to doses of bicarbonate of soda. It is curious at first to find that the administration of an acid seems as potent to aid an "acid" stomach as the administration of an alkali. The reason is the constant salt content of the juices mentioned. Now if chyle from the stomach containing less salts in solution than the normal intestinal juices of the patient does enter the small intestine, the intestine promptly rejects it back into the stomach to protect its own delicate walls. The patient regards this regurgitation as evidence of an acid stomach. Yet it is a regurgitation from the intestine, and the stomach may be twice or thrice as acid as normal without the patient being aware of it.

In this type of dyspepsia where the stomach salt contents are too low—it may have been the high blood-pressure patient who has stopped eating salt on the advice of his physician—either hydrochloric acid or sodium bicarbonate can be administered with good results. For either one will raise the freezing point of the stomach contents, and the small intestine will then no longer reject the spurts of chyle from the pylorus. Digestion will proceed minus the belching and the sense of fullness, for the stomach is emptying normally. (Apperly, *Medical Journal of Australia,* 1926, XXVII, 354; *Journal of the American Medical Association,* 86, 1847; *British Journal of Experimental Pathology,* June, 1926; Van der Laan, *Biochemische Zeitschrift,* 1915, LXXI, 289; LXXIII, 313, 1916.)

Let us return to food fallacies. A popular admonition is "Avoid an acid diet!" A tendency towards dietary alkalinity is preached as eloquently as if there existed incontrovertible experimental evidence to show that a long-continued acid diet is injurious. There is no such evidence. In fact, while a tremendously acid-forming diet had no ill effects on experimental animals at all, a long-continued alkaline diet did have definite bad effects. (Addis, MacKay, MacKay, *Journal of Biological Chemistry,* 1926, LXXI, 157.) (Sherman, *op. cit.,* page 296.)

Nor has an acid diet yet been shown to cause nephritis. Again the body's tremendous reserve power of adjustment must be remembered. It is plain that the body can easily adjust to or neutralize the acid or alkali excess of any normal diet. This is not to advocate a purely acid-forming diet of meat and egg yolk. The idea is simply to draw attention to the fact that fanatics constantly overemphasize a factor here which can not yet be proved to have the importance they attach to it.

As a matter of simple fact lowered blood alkalinity and what is clinically called "acidosis" are concomitant, but this does not necessarily relate them as cause and effect. The proteins, the phosphates and the hemoglobin of the blood enable it to carry large excesses of acid without any alteration whatever in its normal reaction. The true alkaline reserve of the body is not the blood bicarbonate of soda, formed in part by eating fruits, but the blood hemoglobin. The intensity of blood alkalinity is a function of the respiration rather than of the diet.

The causes for the variations in the blood reactions are not acid-alkali neutralizations such as occur in test-tubes; they are deep-seated respiratory and metabolic changes which are imbedded in the intricacies of cellular life and are not yet thoroughly understood. The prevalent emphasis upon acid diets and "alkaline reserves" is unscientific. In fact, as L. J. Henderson says, "within wide limits of amount any acid or base may be poured into the organism, and the reaction will not vary . . . the urine is variable, the ingesta are variable, even

the products of metabolism are variable; but while life endures," the body reaction persists essentially unaltered. (Henderson, Y., *Physiological Reviews*, 1925, V, 131; Wilson, same, 1923, III, 295; Henderson, L. J., *Science*, 1913, XXXVII, 389, and Harvey Lectures, 1914–15, "Excretion of Acid in Health and Disease.")

To return to the dogmatic faddists, we shall use quotation marks to set off their pronouncements. "Milk, starch and fruit is an acid-forming combination." This would depend altogether upon how much of each element you had in the combination, for certain fruits could readily render it alkaline. "Never eat but one kind of starch at any meal." This prohibits a necessity that one can scarcely avoid and eat at all; eating ordinary foods you are almost bound to eat starches from more than one source at the same meal, although there is obviously no reason for two major starch dishes at one meal.

One of the most insane food fallacies is that which appears over and over again in the admonitions of quacks and is even subscribed to by some regular physicians —"Do not eat proteins with starches!" Nothing could be more absurd, for no harm whatever inheres in this procedure so long as whole wheat bread or beans digest well. Nature continually supplies this very combination in legumes and cereals and we are not accustomed to pry protein from starch before eating. Milk itself contains a complex carbohydrate and protein. Furthermore, when proteins are eaten they unite with the stomach acid and thus tend so to lower stomach acidity that there is more likelihood of alkaline salivary digestion proceeding unimpeded than if protein were not present to absorb some acid. Pragmatically the habit of eating starches with proteins is above reproach, for healthy people do this habitually and without detriment. (See Stiles, *op. cit.*, for proteins uniting with stomach acids.)

Indeed, no conclusive evidence exists in the literature to show that a subnormal rate of any of the alimentary processes is caused by the addition of carbohydrate to a diet. On the contrary, the report of Cannon (*American Journal of Physiology*, 1904, XII, 387) that a mixture of carbohydrate and protein foods leaves the stomach more rapidly than protein alone "makes it very probable that the addition of carbohydrates to the diet accelerates digestion and the discharge of the gastric contents." (Mendel, Lewis, *Journal of Biological Chemistry*, 1916, XVI, 37.) The idea embodied in the warning against eating proteins and starches together is a food fad of the most vulgar sort, yet perhaps millions of neuropaths and near psychopaths follow the admonitions of ignorant physicians and palpable quacks in this matter.

Again, we hear, "Exile granulated sugar! Eat only simple, predigested sugars like honey or maple-sugar!" There is nothing harmful about granulated sugar; it might become harmful if some imbecile ate so much of it that other foods were neglected, but used with judgment it is harmless, even beneficial. Few ever eat it to dangerous excess. Sugar can not cause stomach fermentation, because the high acidity there probably renders fermentation in the stomach impossible anyway. (Hurst, of Guy's Hospital, London, *British Medical Journal*, October 2, 1920, 501.)

In addition the body is well provided with enzymes and acids which break down the twelve-carbon cane-sugar—sucrose is its chemical name—into the only sugar the body can directly utilize, the simple six-carbon sugar called glucose or dextrose. Milk-sugar has even to be broken down to glucose and it is just as difficult for us to digest as sucrose; yet nature supplies milk-sugar (lactose).

Nor is there any specific food virtue in

honey beyond its pleasing flavor. It contains no vitamins. It is of course partially digested, because it consists of one half glucose and one half fruit sugar (levulose or fructose); both six-carbon, simple sugars. But the fructose has to be made over into glucose by some mysterious alchemy in the organism before the body can utilize it, so half the honey also has to be worked over. Indeed, glucose is usually stored first in the liver as a kind of complex starch called glycogen; it is then drawn out from this organ into the blood as needed, the glycogen simplifying into glucose for the purpose.

Maple sugar, on the other hand, is, as is generally known, except for a few physicians, simply the same old twelve-carbon sugar, sucrose, found in the beet, in the cane and in the sorghum. It is true that honey and maple sugar contain more mineral matter than cane sugar, but the minerals are not particularly valuable. Potassium, of which we always get sufficient, predominates. The calcium in maple-syrup is about the same in amount as in milk, but one would have to use a quart of maple-syrup daily to get an ample supply, and who would do that? Honey contains a negligible amount of calcium, the element we are most prone to lack in our diet. (Sherman, *op. cit.*)

"White of egg promotes acidosis and autotoxemia." This is really rather amusing to the chemist who is aware that investigators always use egg yolk when they want to give animals a highly acid diet experimentally. (Sherman, *op. cit.*, page 296.) The sulfur content of the yolk also makes it far less likely to cause intestinal putrefaction than the white. Of course the yolk contains valuable vitamins and proteins; but it is high in acid-producing qualities and the white is not.

"Chew long and well. Chew starch to a liquid state." This advice seems to ignore the fact that during a meal the stomach is packed with food from the center outwards, thus gradually forcing the walls apart to store food layer upon layer. Just so food is thoroughly moistened with saliva in the mouth, then alkaline salivary digestion can continue in the center of the massive food bolus in the stomach long after a meal. It actually takes quite a while for the stomach acids to eat their way into the center of the alkaline ball of food stored in the upper part of the stomach where the walls do not move appreciably anyway. (Stiles, *op. cit.*, on Salivary Digestion.)

"The bread, butter, meat and potato mixture is a very harmful food combination." This is almost grotesque. If such combinations of food elements are harmful then milk must be harmful, for it too is composed of protein, fat, carbohydrate and mineral matter. The mixture is, instead, the rational basis for an excellent diet; add some raw or nearly raw leafy vegetables and milk *ad lib* and you have a complete ration.

"Cooking ruins food. Cooking is civilization's curse to food." Raw food faddists widely preach this unadulterated gospel. Even many physicians emphasize raw food too strongly. Of course we need some raw food. And cooking carelessly (usually too long) will render vitamins inert. But at the same time cooking is far from being civilization's curse to rational food. Instead it actually renders certain meat and legume proteins very much more digestible and useful to our organism. (Jordan Lloyd, "Chemistry of the Proteins.")

A very curious example of diet fallacy might well be mentioned here; that is the time-hallowed theory that raw egg white is a singularly nutritious food, easily digested and rapidly assimilated. Many physicians still promote this fallacy, yet nothing could be further from the truth. Mendel and Lewis (*Journal of Biological Chemistry*, 1916, XXI, 55) and Bateman (same, 1916, XXVI, 263) separately

demonstrated that raw egg white is exceedingly indigestible, although slight cooking would immediately render it biologically useful. Dietitians are, therefore, always in error when they assume that a raw egg is especially digestible; the egg slightly cooked is at its best.

Then, again, bread has been found to be much more digestible and much more useful biologically than raw cereals. Raw rice has, indeed, been found to retard the growth of experimental animals and the same holds for puffed rice! (Morgan, *Proceedings of the Society of Experimental Biology and Medicine*, 1926, XXIII, 353; Waterman, Jones, *Journal of Biological Chemistry*, 1921, XLVI, 9; XLVII, 285.)

Of course, we may expect anything of faddists and quacks, as *The Journal of the American Medical Association* always robustly assures us, and as any regular physician will at once aver. But why should an active legitimate physician, for instance, tell a man not to eat eggs because they make the blood a good culture medium, thus promoting infection? A prominent physician recently gave that advice, whereas blood is normally an ideal culture medium for bacteria and egg proteins can yield to it only some of the score or so of "amino acids" into which all proteins break down during digestion. No proteins can pass directly into the blood stream as such; if they did so the consequence would be disastrous.

A physician has recently written a guide to nutrition in which he actually says, "Eat only one protein food at any meal." This is precisely what we should never do. Proteins, as noted above, are built up of simpler substances called "amino acids." There are about twenty of these and we perhaps need most of them to build our own tissues. One protein will very often supply the amino acids which are deficient in another protein and may thus become limiting factors in our nutrition, hence protein combinations buttress each other and are just exactly what we should eat in order to be assured that we get all the varieties of amino acids we need in tissue-building. This is a well-established fact as reference to Stiles, "Nutritional Physiology," will show. (See McCollum, *Journal of Biological Chemistry*, 1916–7, XXVIII, 483; 1917, XXXII, 303; 1919, XXXVII, 155–158.)

A prominent stomach specialist recently told an ulcer patient of his not to eat sugar but to eat all the honey he wanted! This is absurd when you remember that honey is simply sugar. Why do orthodox physicians often presume to advise so freely and so mistakenly on diet? There are actually still practitioners who tell nursing mothers to avoid emotional excitement as it will poison their milk! Yet this is a metaphysical assumption without evidential background save of the type that "proves" miracle.

Three arresting considerations stand out.

1. Physicians are either improperly trained in nutritional physiology or else they make no real effort to absorb the authoritative facts regarding the subject later in life. Perhaps facilities have not been sufficiently perfected to enable them to get really reliable information that they can use practically. Certainly medical education stresses a large amount of purely theoretical physiological chemistry entirely too much, and to the utter confusion of the medical student, when much less time spent upon certain established fundamentals of practical value would better train the future physician. In later life physicians tend to catch here and there an assumption—perhaps in some chance article, perhaps from a group of essentially uncontrolled clinical cases—and that casual impression becomes with them thereafter an article of faith and a permanent dogma.

Experiments may disprove the idea, clinical records of controlled cases may refute it statistically, common sense may find it revolting, but it remains to the particular physician an unalterable, inerrant procedure for all time and for all patients. Yet human beings are seen by science to be more definitely individualized than was ever before imagined, when biological tests were less delicate than now, and no two clinical pictures of the very self-same disease are ever identical.

2. Perhaps physicians do not know where to go for reliable information on nutrition. Very often if they do stumble upon the right authority they are casual and hasty and seem to gather fragmentary or erroneous impressions from what they read. This arises largely from the old antipathy between clinical cases and physiological experiments. The physician has luck with certain dietetic procedures in a few specific but, from the standpoint of rigid physiological experimentation, essentially uncontrolled cases. Then, just like a quack, he makes a snap generalization from insufficient data and proceeds thereafter upon this theory forevermore. The scientific biological or physiological chemist works on carefully inter-bred, rigidly controlled experimental animals under meticulously regulated conditions and he gradually piles up masses of results upon these standard animals which lead to the formulation of really reliable conclusions. He then generalizes cautiously and his generalizations have real value.

The physician constantly voices the ignorant layman's stock objection—but what do experiments with rats or dogs or guinea pigs have to do with the physiological processes of human beings? A very great deal. Nearly all therapy is founded upon animal experimentation. For one thing, certain animals, like the rat, are very similar to man in diet and in nutritional physiology. These animals can be bred under standard conditions throughout many generations over long periods of years. Finally the individual rat is as near a physiological unit standard as can possibly be produced. Human beings would be vastly better of course, but they simply can not be bred intensively throughout dozens of generations to be used in nutritional experimentation. Yet results on standard rats are found time and time again to have human applications. While we should prefer human standards, rats must be used in fault of better, but these rats are far more reliable in their reactions than uncontrolled and diseased human beings under the doctor's very fragmentary supervision. Yet the physician remains skeptical.

3. There is no unalterable rule of diet universally applicable to all men. Human beings differ in health and in disease. Individual measures must always be invoked. Diets also are made up of a large number of essentially individual factors. No dogmatic rule can be laid down. Individuals must try to adjust these various diet factors to their personal needs, judging largely by their state of health. Of course certain basic principles exist with which all practicing physicians should thoroughly acquaint themselves in order to advise their patients wisely on nutrition problems. It would also be a great help if papers and periodicals which glory in printing the most highly technical food-fad systems would get over their aversion to the publication of the plain, fragmentary facts about scientific nutrition in order to instruct intelligent readers. The faddist, the fanatic, the quack or the physician can not avoid error when they extol some universally applicable diet system in health or in disease. It is melancholy to consider the false information dispensed so widely on nutrition.

In conclusion the nature of the basic principles will be very briefly indicated. McCollum has long emphasized the fact

that the American diet is to-day deficient. Such a diet, consisting of milled cereals, legume seeds, meat and deficient amounts of milk have proved inadequate in calcium and in vitamin A and have prevented rats from reaching maximum size or exhibiting maximum fertility. A menu made up of such food does not appear so frightful. For instance—

Broiled Steak		Mashed Potatoes
Buttered Beets	Combination Salad (Or Gelatin, Peas or Carrots)	
Bread	Butter	Sweet pickles
Apple Pie	Cheese	Coffee

"When a family is confined to such food supply throughout several generations, the physical development gradually deteriorates. They show signs of senility rather early and fail to maintain a well-nourished appearance," writes McCollum. It is only necessary to add calcium and fat soluble A vitamin to change this picture completely. In other words, milk consumption must rise from half a pint to a quart *per capita*, since milk is the most accessible source of calcium we have. The consumption of butter, cheese, creamed soups, leafy vegetables, greens and salads must increase. Most important are such vegetables as spinach, turnip, beet tops, celery leaves, romaine, collards, lettuce, cabbage, cauliflower, endives. Legumes, cereals, tubers and fleshy roots, it must be remembered, are calcium-deficient and calcium is an absolute essential.

We may therefore conclude that if a person will drink ample milk and eat freely raw or lightly cooked green vegetables and raw fruits—to round out the ordinary basic diet, the fundamental requirements of nutrition have been fulfilled. Other adjustments are largely a matter of taste.

We do not for a moment conclude that the nutritional laboratory investigator knows it all. We are trying to show that what is actually known as fact to the scientific investigator in nutrition is as nothing compared to the vast assumed knowledge of *soi-disant* diet "experts" and food system faddists. We must learn that scientific nutrition rightly lags far behind these grandiose evangels with their assured "truths." But slowly and laboriously the foundation is being placed for a science of nutrition that will be immeasurably valuable because it is rigidly scientific. All people of intelligence should know about this. They should be eager to know of scientific progress rather than eager to follow the syndicated words of sciolists.

THE ACTION OF ALCOHOL ON THE BODY AND ON ITS OUTPUT OF WORK*

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Introduction

In a discussion of the effects of alcohol on the body, we are confronted by two outstanding questions: What does alcohol do to the body and how does it do it? In considering these questions we shall look first at its action on single exposed cells. Second, we shall study its action on an organ separated from the body, and, third, we shall consider its effects on the whole body.

We may say summarily that: (1) It takes a concentration of alcohol as high as two per cent. to cause permanent injury to a single free swimming cell; (2) a concentration of one eighth per cent. does not injure an organ like the heart when that organ is removed from the body and kept active, but (3) the same concentration, one eighth per cent. in the blood stream, may seriously injure the whole body. Indeed, one half of one per cent. in the blood stream not infrequently causes death. We shall see further that the advantage which alcohol in the blood stream has over alcohol bathing a muscle is that in the blood stream it has ready access to the brain. The brain is the organ in command of the body, but at the same time it is the one organ of the body which is most susceptible to the action of alcohol.

Let us look in detail at the three types of experiments.

Action on Exposed Cells

If we add a sufficient amount of pure alcohol to a medium in which unicellular organisms live so as to bring the medium to a one per cent. alcoholic solution, the first effect to be noted is on the behavior or activity of the cells. In most cases after a moment of quiet, the organisms become active and move rapidly about as if attempting to escape injury. If the alcoholic concentration be increased to two per cent. the cells may or may not continue motor reactions. They contract and round up. In a concentration of four or five per cent. the cells swell up and rupture and the protoplasmic contents run out, thus causing the death of the cell.[1]

Action on Groups of Cells or an Organ

We may test the action of alcohol in known percentages on a given organ, for example, a muscle, by isolating the organ from the body. By this means we may ascertain at what strength the alcohol first has a *direct* effect on the muscle and we may then study the nature of the effect. Let us look briefly at the problem involved if the isolated heart is the muscle considered.

Martin and Stevens early found that alcohol could be added to defibrinated blood and then this mass passed through the isolated heart of the dog. When the alcoholic concentration was kept at one eighth per cent., the mass had no apparent effect on the heart muscle. At one fourth per cent., however, it usually lowered the activity of the heart and at one half per cent. it resulted in a rapid

* The fourth of a series of articles on "Alcohol from a Scientific Point of View."

[1] Daniel, J. F., *Journ. Expt. Zoology*, Vol. 4, p. 575.

and marked diminution of the work done by the heart. From these experiments, it appears that alcohol of one eighth per cent. has no effect when applied *directly* to the heart muscle. In fact, it is not until the concentration reaches or nears one fourth per cent. that an effect is discernible.

When the heart is intact in the body and integrated with the nervous system it is difficult to make certain just what action the alcohol has on the heart as an organ. We know that alcohol simply held in the mouth may quicken the heart beat, but this effect is neither prolonged nor profound. A similar result may be obtained from a number of other irritants. As to effects other than these which are temporary, we are little informed. Dodge[2] in summarizing the results of the many studies made on the effect of alcohol on the pulse rate shows that the experiments on this subject divide themselves into four groups. In one group, alcohol definitely increases the pulse rate; in a second, it decreases it; in a third, it neither increases nor decreases it; and in a fourth, it both increases and decreases it. In contemplating these results, our first impulse is to reject them as inaccurate and valueless. But many of the experiments, under the conditions studied, were very accurate. From these studies one thing is clear, and that is that the heart with its complex system of accelerators and brakes is a superbly stabilized mechanism which alcohol can overcome only provided it be administered in relatively large doses.

In order to insure a concentration of one eighth of one per cent. alcohol in the circulation of a man of 150 pounds weight, Abel[3] has shown that it would be necessary to give the equivalent of about six ounces of whiskey in the course of a single hour, a dose which in most cases would produce intoxication. We have seen, however, in the experiments of Martin and Stevens that this concentration has no effect on the heart when isolated from the body. Why is it that the same concentration may have so marked an effect on the body when the heart is intact?

It has long been known that alcohol readily injures the nervous system which is in control of the orderly functioning of the body; but even to-day it is not certain just how this effect is produced. An example will illustrate this point. Normally, there is a beautiful adjustment between the nervous system and the muscular walls of the blood vessels of the skin, regulating the amount of blood which goes to the surface. Alcohol, often in small amounts, destroys this adjustment and as a result, too much blood rushes to the skin. Does the alcohol in this case act on the nerve centers; or on the nerve fibers, running from the center to the skin; or does it act on the connection which the fibers make with the muscles in the walls of the blood vessel? The best evidence which we have at present indicates that the action is on the nerve center in control of the muscular wall. By action on (depressing) this center, alcohol is able to cut off the nerve impulse to the vessel and consequently to leave the muscle practically in a state of paralysis. The muscular walls of the vessels thus released from the integrating action on the nervous system relax and the caliber of the vessels increases enormously in size. As a result of these several steps the blood under pressure from the deeper vessels rushes to the surface, and the face and upper parts of the body flush pink.

If the injuries of alcohol are primarily through the nervous system, it would appear that one of the factors in the degree of injury would be the degree of development of the nervous system. In a man with numerous highly developed nerve centers alcohol would undoubtedly

[2] Dodge, R., and Benedict, F. G., Carnegie Inst. Publ., Washington, No. 232, pp. 186–7.

[3] Abel, J. J., "Physiological Aspects of the Liquor Problem," Vol. 2, p. 50.

have a wide field of attack, for in him alone are found certain of the more complex centers, like that of speech for example. But its effects on certain types of coordination, for example, on locomotion, might be expected to show themselves earlier in man because of his method of locomotion. I shall consider the latter point first.

Action on Muscular Coordination

One of the most prominent symptoms of the action of alcohol is the general incoordination which it produces in the muscles of the body. Especially is this true in those muscles associated with locomotion. According to Mellanby,[4] the steps in the development of this condition in the dog, while not exact, may be followed in a way. The first symptom of incoordination in the locomotion of this animal is the dragging of its hind toes. This generally occurs at a time when the concentration of alcohol in the blood reaches about 354 cubic millimeters per 100 grams of blood. Following this step are others, such as weakness in the hind legs, stumbling, difficulty of getting up after falling, inability to walk and finally complete collapse. The degree of injury to the coordination of the muscles is here reflected in a series of steps which become more and more pronounced until finally muscular coordination is entirely destroyed.

In man alcohol acts on the muscular coordination involved in locomotion earlier than it does in the dog. The main reason for this is easily understood. It has been pointed out that the dog first shows weakness in its hind legs and that this weakness makes it more difficult for the dog when intoxicated to stand still than to walk, for by walking the faltering of the hind legs is, as Mellanby (*loc. cit.*, p. 31) says, compensated for by the front legs and the muscles of the body. In a bipedal type like man, however, the whole support of the body depends on the legs, but here the base is relatively small. As a consequence, balance is difficult and any unsteadiness is early detectable. The breaking down of the coordination of the muscles of locomotion, then, is more readily attained in man than in the dog. This would be true regardless of whether alcohol acts in a more pronounced way on the nervous system of man than on that of the dog; it would affect his locomotion earlier because it acted on a more delicately adjusted mechanism.

To illustrate in a simple way the extended field of attack we may cite an example, also in muscular coordination, in which the movements of the hand, the arm and the eye are involved. The following series of drawings (Figure 1),

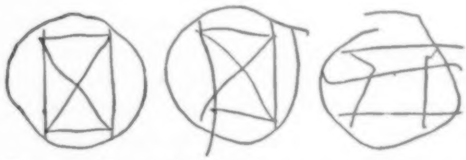

Fig. 1. Drawings made by a subject at different intervals (27, 43, and 55 minutes) after imbibing whiskey. From Mellanby.

made by a man after taking whiskey indicates the character of the effect in acts of this sort.[5] Here it is seen that the alcohol is more and more effective in breaking down coordination up to a certain maximum for the dose. While the first drawing shows irregularity, it is not until the third, made fifty-five minutes later that incoordination is at its maximum. It is at about this time, as we have shown in a former article,[6] that the alcohol reaches its highest concentration in the blood and presumably has its greatest effect on the nerve centers.

[4] Mellanby, E., Report No. 31, 1919, Med. Research Committee, London.

[5] Mellanby, E., *British Journ. Inebriety*, Vol. 17, p. 175.

[6] Daniel, J. F., The Scientific Monthly, Vol. 18, p. 160.

Beyond this time, coordination rapidly improved.

Action on Other Types of Coordination

The action of alcohol on pure muscular coordination, however, is only one of a number of ways in which alcohol may express itself in man. Some of the ways, as is well known, involve complex psychical factors as well as physical factors. It is a common observation that man under the influence of alcohol may become garrulous and that this symptom of the activity of the alcohol may appear early, like the purely physical coloring of the skin.

If this reaction be compared with that on muscular coordination, the two may at first appear to be diametrically opposite in effect. In the case of muscular coordination, as we have seen, alcohol by removing certain inhibitions, impairs the normal functioning of the body. It renders locomotion difficult, the execution of a drawing inexact, and the contraction of the cutaneous blood vessels well nigh impossible. In case of the effects now under consideration, alcohol appears to assist function. The subject talks more freely and his ideas come without effort. Inwardly he marvels at the fluency of his expression. He would say that never before was his conversation so effective or his opinions so much appreciated. If, however, his expressions be dictographed and reviewed by him after the effect has worn off, they would make a different impression on his mind. Although his conversation was voluminous, it was inconsistent and emotional.

In the above reaction, then, alcohol has also impaired function. By releasing inhibitions a more voluble expression results, but the character of the expression indicates impairment of judgment.

By the possession of these varicus indicators which we have cited, man should become an unusually good type on which to study the action of alcohol were not the difficulties of the problem so great. But let us examine more minutely the effect of alcohol on the output of work beginning with the simplest muscular acts.

Effects of Alcohol on Work

Many of the earlier experiments dealing with the effects of alcohol on muscular activity dealt with complexes so involved that an analysis of any part of the complex was, at the time, difficult or impossible. For this reason it was found desirable to plan experiments which if possible dealt with simpler activities or reflexes of a kind divorced from the influence of volition. Such an experiment on a reflex act would inform us of the action of alcohol on that reflex arc in terms of how the muscle acted, whether its activities were increased or decreased. This could be measured mechanically and accurately. In recent years, important work of just this sort has been undertaken by the Carnegie Nutrition Laboratory and I shall refer briefly to the parts of the report by Dodge and Benedict (*loc. cit.*) dealing with the action of alcohol on the knee-jerk and on the protective reflex of the eyelid.

Effects on Simple Reflexes

In experiments on the knee-jerk, the tendon below the knee was struck and the contraction of the muscle of the thigh (the quadriceps) was recorded. The questions raised were: (1) Will a moderate dose of alcohol (29.8 cc) hasten or check the promptness with which the muscle contracts; and (2) Will it increase or decrease the amount of the contraction? As a result of these experiments it was shown that in five

men out of six the response or promptness of the reflex was slowed down almost ten per cent. (9.6 per cent.) and the extent or height of contraction decreased nearly forty-nine per cent. (48.9 per cent.). As regards both promptness (latency) and extent (height) of contraction, therefore, a moderate dose of alcohol produces a depression of the knee-jerk or patellar reflex.

The protective eyelid reflex has a normal latency equal to that of the knee-jerk. Because of this fact it was considered a satisfactory reflex to compare with the knee-jerk. In addition it has the advantage of representing a higher level than the patellar reflex. The stimulus used in the protective lid reflex was auditory, and was made by closing a wire-loop hammer against a sounding-board. In these experiments, record was taken by photographing the shadow of the eyelash as a "bat" of the eye. The dose of alcohol (29.8 cc) checked the latent time or the promptness with which the eye-bat occurred in four out of six subjects by an average of more than five per cent. (5.9 per cent.). It also decreased the extent of movement in five out of six subjects by an average of more than ten per cent. (10.7 per cent.). Furthermore, forty-five cubic centimeters of alcohol increased the latency in five cases out of six, 9.5 per cent. and decreased the extent of movement 28.5 per cent.

In both of the experiments given above, moderate doses of alcohol reduced the efficiency of the muscle.

Effects on Skilled Acts

A voluntary act like that of typing which includes a number of mental attributes, such as attention, memory and the like, may with practice become almost automatic. In a nicely adjusted activity of the sort, what will be the effect of alcohol on speed and on accuracy of performance? To test these two questions Vernon[7] has recently made an extended series of experiments which consisted in typing a memorized passage successively before and after the ingestion of alcohol. After the control experiments were repeated at twenty-minute intervals alcohol was given and the typing was continued for the subsequent two and one half to three and one half hours. The alcoholic liquids used were taken over an interval of one half hour and were taken practically on an empty stomach.

As regards speed the results are not convincing. They indicate that the typing time was increased in all but three of the examples, and an increase in typing time would, of course, indicate loss in speed. As to the effects on accuracy the results are very suggestive. Vernon found that, under alcohol, the errors increased in some cases as much as fourfold. He found, further, that when the alcohol was taken on an empty stomach, its effects were about twice as great as when taken with meals. Vernon cites one subject very susceptible to alcohol, who, after taking 11.2 cubic centimeters (less than one half ounce) of pure alcohol on an empty stomach, made an increase of 88 per cent. of errors. Another subject, after drinking sherry containing 22 cc of alcohol, made an increase of 156 per cent. On the other hand, some subjects took port containing 18.5 cc or ever 22 cc of alcohol with meals without showing any "measurable reaction."

Miles[8] has recently (1924) published a careful series of experiments on the effects of moderate quantities of alcohol on typewriting efficiency, which agree with the results of Vernon. In these experiments young men trained as typists

[7] Vernon, M. H., Report No. 34, 1919, Medical Research Committee, London.

[8] Miles, W. R., Carnegie Inst., Washington, Pub. No. 333.

were used as subjects. A practice period of two days was given and followed by a period of four days, two of which were control and two alcoholic. The alcoholic dosage "A" was about 0.5 cc. of absolute alcohol per kilogram of body weight; dosage "B" was 50 per cent. larger than "A". Typewriting efficiency was tested in three grades of difficulty: on a memory line; on scientific prose and on nonsense combinations.

As a result on accuracy, Miles says (p. 69): "If the practical excellence of typewritten material is to be judged on the basis of its freedom from such errors or such groupings of errors as make the contents of the material difficult of understanding, then it must be concluded from this investigation that 21 to 28 grams of alcohol given in a 14 to 22 per cent. solution (dose A) reduces the quality of typewriting about 50 per cent. for a period extending 2 hours after taking the alcohol on a relatively empty stomach, and continues to affect the typewriting unfavorably to the extent of about 25 per cent. in the period from 3 to $4\frac{1}{2}$ hours after the alcohol. The taking of 32 to 42 grams of ethyl alcohol in 150 to 200 cc of liquid (dose B) decreases the excellence of the typewritten copy of easy practice-sentence work about 160 per cent. as an average in the 2 hours after the taking of the beverage, and as much as 90 per cent. even 3 hours after the alcohol is taken."

McDougall and Smith[9] have added a series of experiments which tests accuracy of performance. The machine which they used was a mechanical device having a continuous band of paper-tape about an inch wide on which were distributed irregularly but at equal intervals small red circles. As the red circles passed the window at a uniform rate, they were marked. Among the 1,200 red circles on a tape of six meters' length were 90 blue circles which were not to be marked. As the blue circles passed, the right hand had to be lifted to avoid marking the circle. At the same time the left hand tapped a key attached to a recording pen to show if the key had been tapped.

Four types of errors occurred: (a) A circle was allowed to pass unmarked; (b) a blue circle was marked; (c) an extra dot was inserted between two circles; (d) the circles aimed at were not hit squarely.

To test the effect of alcohol on the accuracy of this operation, a dose varying from 10 to 30 cc of pure alcohol mixed with three parts of water was taken on an empty stomach; one hour later the test was made. McDougall and Smith found after a dose of 10 cc an average increase in the number of errors of 21 per cent., after 15 cc of alcohol an increase of 42 per cent., after 20 cc an average of 39 per cent., and after 25 cc an average of 113 per cent.

Conclusions

In concluding this paper we may again refer to our original question: What does alcohol do to the body? With increasing knowledge man's answer to this question has undergone great change. During his early experience with distilled spirits man regarded alcohol as a prolonger of life and as a sort of cure-all. He soon learned, however, that excess is injurious. Moreover physicians have found that the wide application of alcohol to disease formerly practiced in medicine is untenable. To-day its use is restricted largely to two types of cases. First, it may be used as a nutritive in certain types of fevers, and secondly it is often employed more for its psychological effect than for its curative effect. Time will tell to what extent these usages can be justified.

[9] McDougall, Wm., and Smith, M., 1920. Medical Research Council No. 56, London.

Modern experiment has dealt largely with alcohol in so-called moderate doses. From experiments like those on typesetting it early appeared that moderate amounts of alcohol assist in the performance of work. But this has not proved to be the case, for as Vernon, Miles, McDougall and Smith have shown, the work performed is inferior in quality. After Atwater and Benedict proved that the body can oxidize alcohol and the alcohol can be used in work, alcohol was regarded by some as a possible important source of energy. In considering alcohol as a source of energy two phases of the question may be noted: First: We have learned from the studies of Professor Durig on mountain climbing (see Starling, p. 62) that in moderate dosage alcohol can not be used advantageously for hard physical work. Secondly, the amount of alcohol given by Atwater and Benedict (about one half ounce) was a *minimum* dose, a dose which gave no effect of drug action, rather than a so-called *moderate* dose. To define *moderation* in alcohol is a difficult task. If it is true, as recently stated by Starling[10] (p. 174), that "Any dose is immoderate which diminishes a man's efficiency and powers of performing his normal avocations" then we must conclude from the work of Dodge and Benedict, Vernon, Miles and McDougall and Smith that alcohol, even in so-called moderation, may be detrimental to man.

[10] Starling, E. G., 1923. "The Action of Alcohol on Man." London.

By experience then we have learned that alcohol is not a cure-all; that it can be applied advantageously to but few diseases, and that in excess it is injurious. By experiment we have ascertained that even moderate amounts of alcohol may decrease the activity of a muscle and may militate against precision and accuracy in various types of skilled acts.

We are at present especially ignorant, however, of one phase of the action of alcohol. As might be expected, it is precisely on this point that men are in the widest disagreement. One group holds that alcohol is a real benefit to mankind in that through its use men can get relief from "petty worries." As Starling (*loc. cit.*, p. 175) says, alcohol may be used "to produce the increased pleasure in living." This subjective effect is without doubt the reason for social drinking; for the banquet goes better after inhibitions have been removed. A second group maintains, however, that man should be sportsman enough not to need the aid of alcohol to make the banquet "go"; that he profits by cultivating his natural endowments to this end, and at the same time runs no risk of injury to body and mind. These two positions are subject to direct study, and this question, too, will be solved in time.

NEW HARMONY

By Dr. DAVID STARR JORDAN
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INDIANAPOLIS

THE Indiana Academy of Science celebrated from May 12 to 14 the Centennial Anniversary of Western Science in the town where scientific investigation in that region practically began. New Harmony lies in Posey County, the most southern of the 92 counties of Indiana. Posey County occupies the rich and level farming land of the southwest corner of the state, bounded on one side by the Ohio River, on another by the Wabash, the Ohio separating it from Kentucky, the Wabash from Illinois. On the east side, on the Wabash, is the village of New Harmony, with about 1,200 inhabitants, the scene of the great communistic experiment of Robert Owen, who was a prosperous mill owner, well known for his cooperative industrial effort at New Lanark, Scotland. Fertile soil, abundant water, salubrious climate, furnished a favorable setting.

A century and more ago the civilized world began to feel that the age of business competition was passing, and that a new social and industrial era was at hand. This was not the first time nor yet the last when ideal conditions seemed imminent in human relations. Franklin once indicated that if every one would work three hours a day at something useful, poverty would be banished and all men might spend the afternoon of each day and the whole afternoon of life amid the consolations of philosophy, the charms of literature or the delights of social intercourse. In the words of Robert Dale Owen, men "looked forward to the time when riches, because of their superfluity, would cease to be the end and aim of men's thoughts, plotting and lifelong stirring; when the mere possession of wealth would no longer confer distinction any more than does the possession of water, than which there is no property of greater worth."

With the same thought, the geologist, William Maclure, prominent in the Philadelphia Academy of Natural Science, refusing to invest money in Philadelphia, asserted that "land in cities could no longer rise in value. The community system must prevail and in the course of a few years Philadelphia must be deserted and those who live long enough may come back here and see foxes looking out of the windows."

Entranced by these ideas, Robert Owen, of New Lanark in Scotland, successful author of various reforms, came to America to put his conceptions and experiences into practice. With Owen was associated William Maclure, one of the eminent geologists of the day and a friend of scientific men, many of whom he induced to join in a great humanitarian enterprise.

The property at New Harmony was bought by Owen from George Rapp, the head of a celibate German communistic cult, known as the "Economists." These then left Indiana to form a settlement in central Pennsylvania which they named Economy. Under Rapp's rule this experiment was financially successful because it was dominated by a single will. Both his ventures, in Indiana and in Pennsylvania, were ideal Theocracies, ruled autocratically under divine right. According to Rapp an angel appeared at his bedside every morning to direct what each member of the community should do each day.

At the foundation of New Harmony,

Maclure and others came down the Ohio River on a boat named "The Philanthropist." This became locally famous as "The Boatload of Knowledge." It contained all the men of science whom the geologist was able to reach and influence. His plan was to build up in this community a School of Industry which should teach the "Conquest of Nature." Farmers should rise above the status of "tillers of the soil" to leading the land to do its best. A magazine was founded, called "The Disseminator of Useful Knowledge, containing Hints to the Youth of the United States from the School of Industry." In "The Disseminator" appeared from time to time valuable articles from naturalist members of the community.

Thomas Say, one of the founders of the Philadelphia Academy of Natural Science, formerly a member of Long's Expedition to the Rocky Mountains, wrote learnedly on insects, birds and shells. Another pioneer naturalist, the French artist, Charles A. LeSueur, also came to New Harmony with the "Boatload of Knowledge." A friend of Cuvier, with an established reputation as naturalist and artist, he had been around the world on La Perousé's celebrated voyage. In the drawing and painting of animals he showed rare skill, and his woodcuts of the fishes of the Great Lakes are among the most lifelike ever published. It was he who painted the drop-curtain of the Community Hall. This represented Niagara Falls with "the other marvel of the New World," the rattlesnake, coiled beside it. Richard Owen was a favorite with LeSueur and once told Dr. Jordan how he used to wade barefoot in the bayous of the Wabash to gather mussel shells for the gifted naturalist. Three of the sons of Robert Owen—David Dale Owen, Robert Dale Owen and Richard Owen—were each highly gifted, David and Richard as geologists, Robert in literature and the humanities. Robert Dale Owen was long and favorably known as a charming writer, one of the group of essayists who early gave to the *Atlantic Monthly* its high literary character. As a member of the Indiana Legislature he had a large part in shaping the public school system of the state. David Dale, the second son, and Richard, the youngest of this remarkable family, were intimately associated throughout their lives. David, afterward the first United States geologist, was especially interested in fossils and minerals. He classified the great collection left by Maclure, which, with his own extensive accumulations, afterward formed the Owen Museum (of 85,000 specimens) of Indiana University, one of the largest displays of Paleozoic fossils in America until its partial destruction by fire in 1883. In 1886 a large part of this collection was sent to the United States National Museum, in return for the re-identification and restoration of labels lost or destroyed by the fire. The only daughter of Robert Owen who came to America, Jane Dale Owen, a woman of much ability and of considerable scientific knowledge, married Robert H. Fauntleroy, astronomer and meteorologist in the service of the United States government. Upon his death he was succeeded by his son-in-law, Professor George Davidson, the well-known astronomer of the United States Coast Survey, who took up his abode for a time in New Harmony.

The New Harmony school-master, Dr. Joseph Neef, was a blunt, plain spoken, honest man, a great favorite with his pupils. An Alsatian by birth, he had been priest, soldier and at the same time a mathematician of high ability—for a while also, associate of Pestalozzi in his famous school at Yverdon, Switzerland. Pestalozzi once commended him as "an earnest, manly worker, who did not dis-

dain to occupy himself with the elements of science." Maclure met Neef in Paris, and brought him over to America. "It is my highest ambition," said Neef, "to be a country school teacher amidst a hardy, vigorous community." His two daughters both married Owens, the one David Dale, the other, Richard. Another who came on "The Philanthropist" was the Dutch scientist, Dr. Gerard Troost, who remained for some time, becoming state geologist of Tennessee.

Richard Owen was professor of natural science in Indiana University from 1863 to 1879, where Mr. Butler was one of his pupils. Dr. Jordan was chosen as Richard Owen's successor. Owen was a man of broad scholarship and large sympathies as well as of courtly manners. Dr. Jordan gave a lecture in New Harmony with Dr. Owen in the chair. He was then very old and heard not a word which was said, but by watching the faces of the audience he was able to exhibit every appropriate shade of feeling for which the address seemed to call.

Many distinguished visitors came to New Harmony, among them Sir Charles Lyell, greatest of all geologists, who was once a guest of the Owens. Constantine Rafinesque, eccentric and ultra individualist, also passed that way "on foot, with a bundle of plants under which a peddler might groan."

The New Harmony experiment, based on Communism, lasted but a short time. Its failure was in its economics; its successes in the study of nature. Some blamed Owen himself for his refusal to deed to the Community all its property. He chose to wait to see how it turned out. Common opinion asserts that it had "too many managers and too few workers." Common ownership requires community of spirit. Drones and workers can not have equal access to honey cells, a fact that has many times been demonstrated. But from another point of view—that of common life among free spirits—"Gemeingeist unter freien Geistern"—the episode must be reckoned a great success. It marked the advent in the Middle West of serious work in science. More than any others, Owen and his sons were advance leaders in the progress. The beginning of the United States Geological Survey was the work of David Dale Owen, and till near the time of the Civil War, its actual headquarters were at New Harmony. The Brookville Natural History Society, founded by Amos W. Butler in 1881, caught its first inspiration from Owen and Say and it was the chief influence in the founding of the Indiana Academy of Science in 1885.

After the failure of the Owen venture New Harmony continued as a center of scientific activity. The United States Geological Survey, the work of the United States Coast and Geodetic Survey Meteorological Records and the libraries begun by William Maclure in New Harmony and extended throughout the state. It was a training school for young geologists. Among those who worked there were Edward T. Cox, state geologist of Indiana; J. G. Norwood and A. H. Northern, state geologists of Illinois; B. F. Shumard, state geologist of Texas; Dr. Robert Peters, Dr. Joseph Leidy, F. B. Meek and Leo Lesquereux.

It is fortunate that so much has been preserved for a century, that the Indiana Academy of Science has felt the urge to pay honor to the memory of these pioneers. For more and more, New Harmony is becoming a place of pilgrimage for the social scientist, the educator, the historian, the student of the natural and of the physical sciences and the tourist. A beaten pathway has been made to the door of New Harmony.

THE PROGRESS OF SCIENCE

EDITED BY EDWIN E. SLOSSON
Director of Science Service

THE SECRET OF SYNTHETIC PETROLEUM

CURRENT discussion in the newspapers of the combination of the Standard Oil Company of New Jersey with the German Dye Trust for the production of synthetic petroleum has made the American public realize for the first time that constructive chemistry has reached a point where it is to be taken seriously in this field. We had heard for some time rumors that the Germans were experimenting in methods for making artificial motor fuel, but then we should expect German scientists to fool around with such a visionary idea. We could understand also why the British, since they had no oil of their own, should take an interest—even a financial interest—in such projects.

But why should we, when our petroleum output had reached an unprecedented height and still had not passed its long-predicted peak, when the oil was pouring from the ground faster than it could be barreled and sold, when the Congress is being called upon to put a stopper on our overflowing wells—why should we concern ourselves with the development of a difficult, expensive and untried process for converting coal into coal oil? A patent for the making of gasoline and other things from coal was among the mass of German patents taken over by the Alien Property Custodian when we entered the war and placed in the hands of the Chemical Foundation for the employment of any true-blue American, but nobody cared to call for it.

But now when we see that the very men who are most active in handling natural petroleum are acquiring the rights for making its synthetic competitor, our papers are full of wonder-why editorials. Two kinds of answers are prominent: first, that Standard Oil is preparing for the future when the fluid fossil fuel that we are drawing upon so unwisely and using so wastefully will begin to run out; second, that the process concerned has an immediate application to the working up of heavy oil residues and distillates, asphalts and tars, into gasoline and other valuable products such as alcohols.

Which of these surmises is the main object can not be determined by the public since the particular process to be employed is still a secret. It is known to be based upon the method for the liquefaction of coal developed by Dr. Friedrich Bergius, of Heidelberg, but it is said to involve the use of some unknown catalyst. "Catalyst" is the name given by chemists to a substance which promotes by its mere presence the desired reaction. In this case, for instance, the catalyst may serve to facilitate the joining of the carbon atoms of the coal with the hydrogen atoms from water to form gasoline, somewhat as the brakeman on a train couples together the cars. The original Bergius process was distinguished from its rivals by dispensing with any catalyst and forming the union between carbon and hydrogen by employing high temperature and pressure alone. But apparently for certain purposes that we can only surmise some catalyst is found a useful aid.

The first step in the effort to solve the mystery of the unexplained catalyst is to make a search of the patents recently applied for by the I. G., the combine of chemical industries commonly called the German Dye Trust. One of the catalysts specified is sulphur. Now sulphur is

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THE RECENT ERUPTION OF MOUNT VESUVIUS

SMOKE AND LAVA FROM THE CRATER OF THE VOLCANO DURING A RECRUDESCENCE OF THE RECENT ERUPTION.

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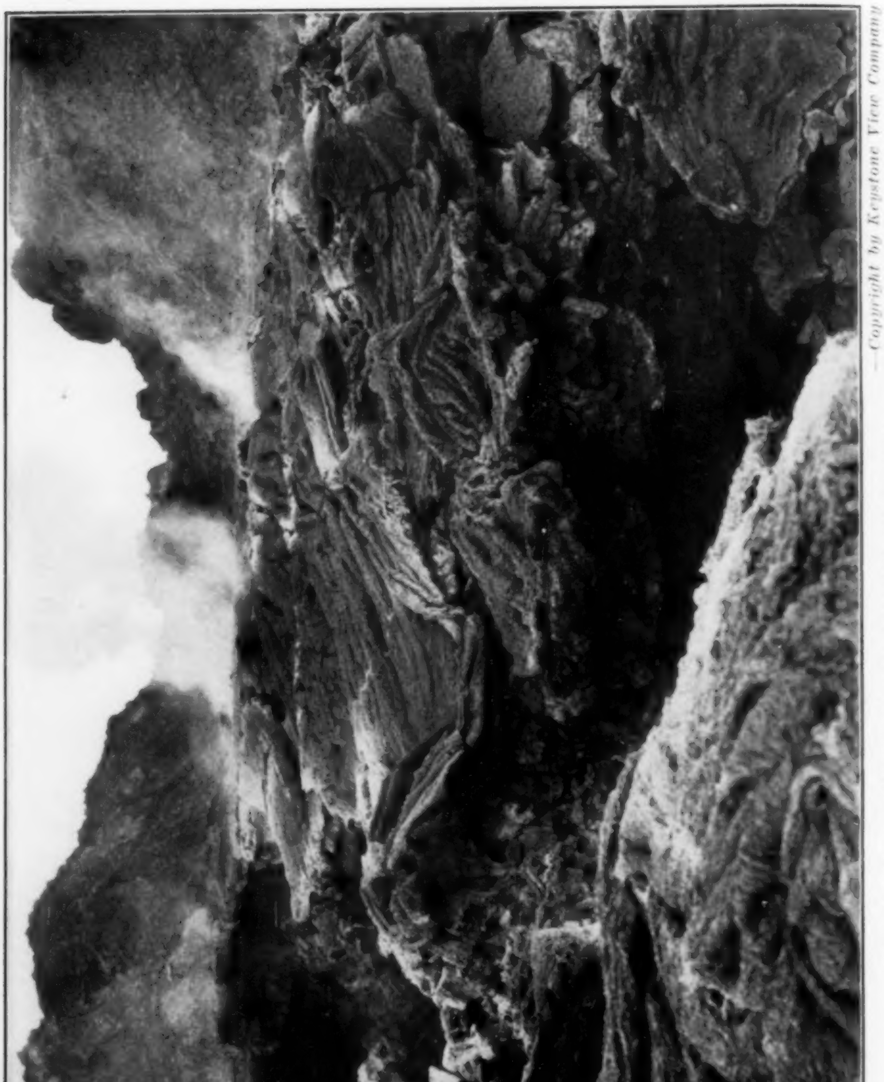
PROFESSOR ALESSANDRO MALLADRA

DIRECTOR OF THE VESUVIUS OBSERVATORY, IS SEEN IN FRONT OF HIS HOUSE WHICH STANDS AT THE FOOT OF MOUNT VESUVIUS; FROM THERE HE OBSERVES AND REPORTS THE ACTIVITIES.

found frequently in coal and oil where it is regarded as objectionable. For many years the petroleums of some of our richest fields were rejected as unusable because of their sulphurous smell until finally a way was found to eliminate the obnoxious ingredient. It would be funny if the element that the chemists worked so hard to get rid of should turn out to be so useful that it is added where wanting. It might be added in the unpleasantly familiar form of hydrogen sulphide which would carry the necessary hydrogen as well.

The high cost of free hydrogen has been regarded by outsiders as an obstacle to the process, but it has been recently revealed that this element may be introduced in the form of steam, or of methane, which occurs in our natural gas or may be made artificially.

Among other catalysts mentioned in the I. G. patents are compounds of nitrogen. Now, nitrogen is also a common compound of coal, or it might be introduced in the form of some synthetic compound manufactured from air. Other catalytic agents specified the rare



THE RECENT ERUPTION OF MOUNT VESUVIUS

THE NORTHEASTERN SECTOR OF THE CRATER OF THE VOLCANO AFTER THE RECENT ERUPTION, SHOWING THE NEW CAVITIES FROM WHICH THE LAVA FLOODS WERE EJECTED.

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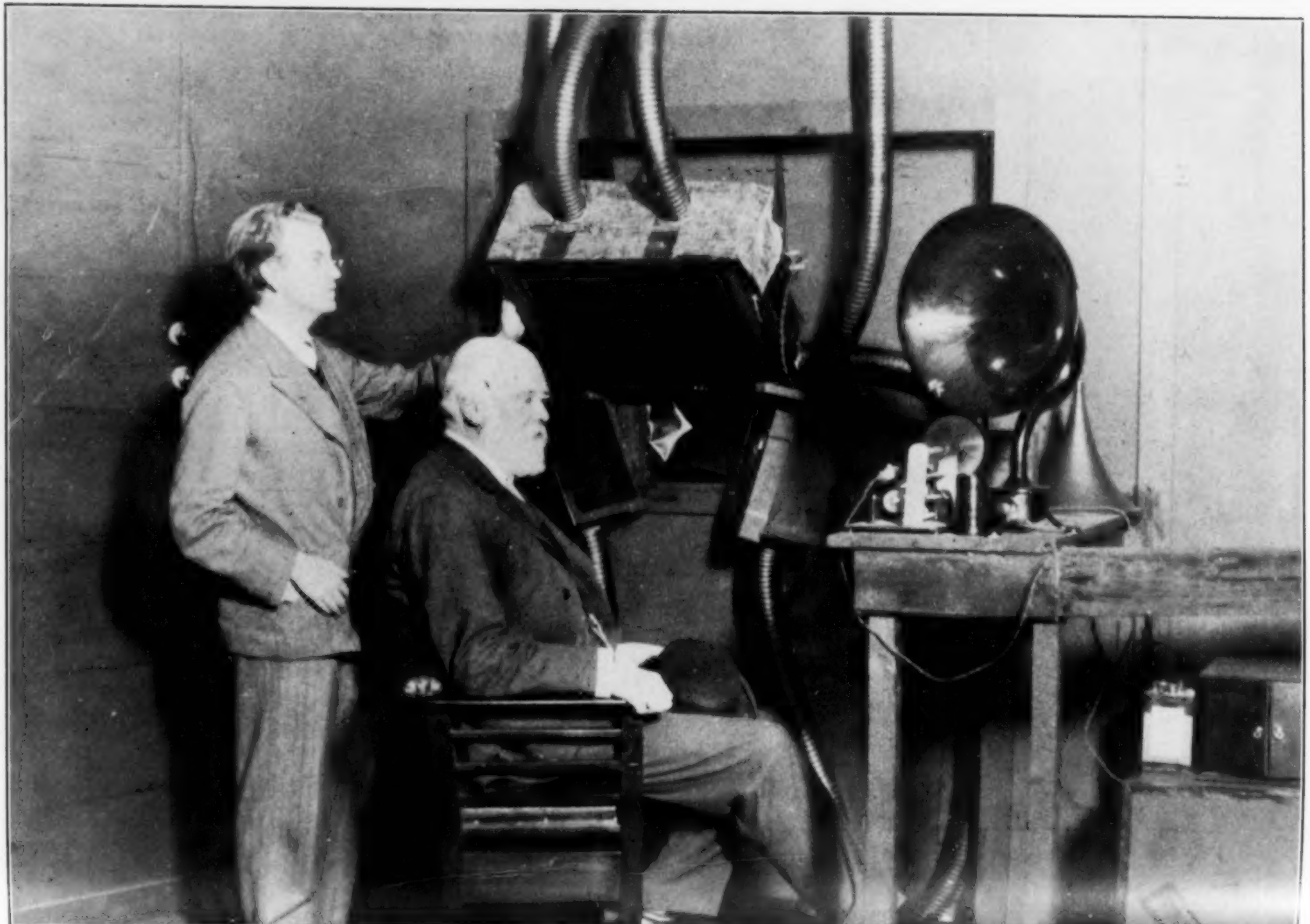
PROFESSOR ALFONSO SENNINO

STUDYING THE RECENT ERUPTION OF VESUVIUS AT THE SIDE OF THE CRATER.

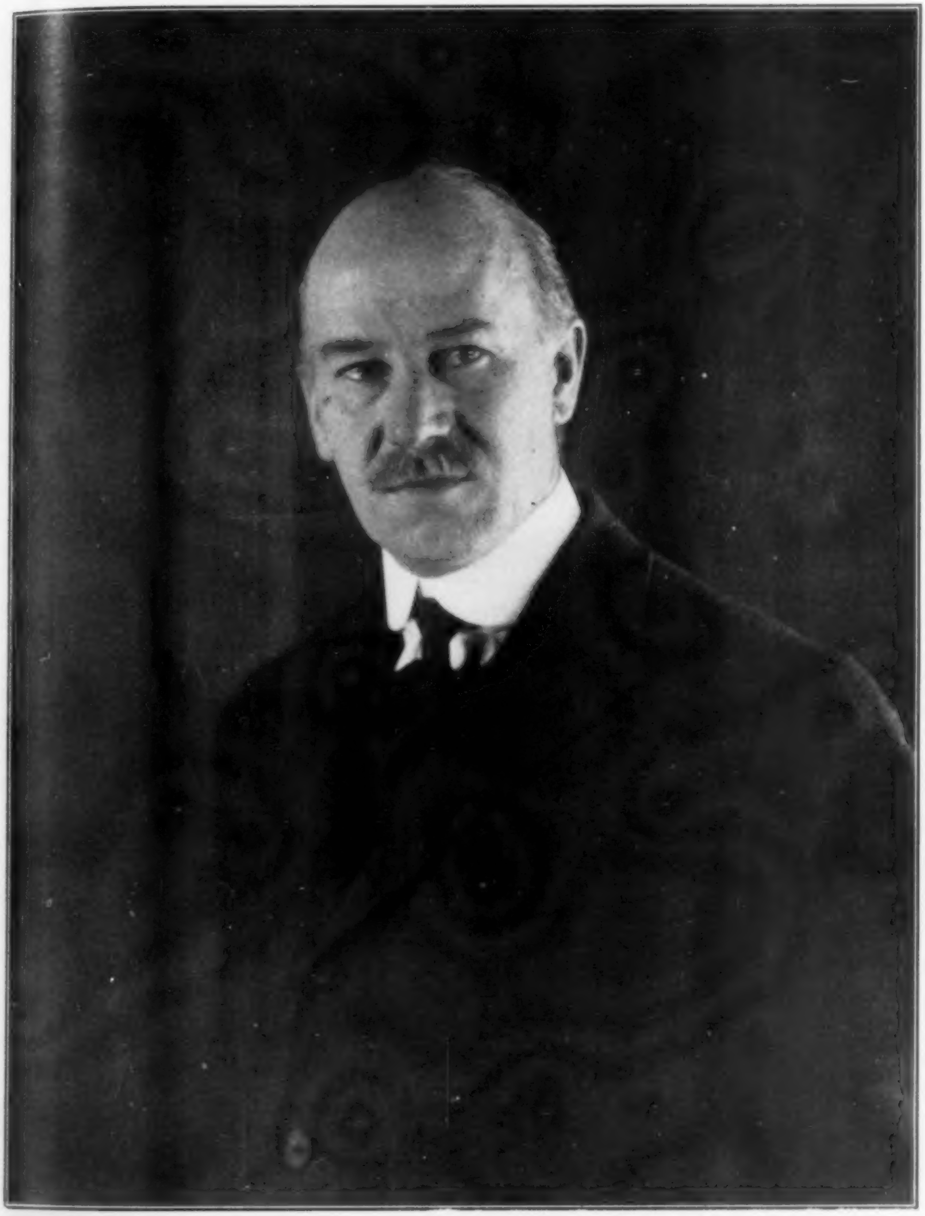
—or until recently unfamiliar—metals molybdenum, tungsten and chromium, and their compounds, and so many other substances that it is impossible to guess which is to be most employed.

Dr. Bergius explained his process for the transformation of coal into oil before the Pittsburgh Conference on Bituminous Coal with remarkable freedom and frankness, but it was noticed by the audience that he said little or nothing about its catalytic possibilities. In the discussions of the conference several of the experts present tried to elicit his views on this crucial point. His final answer is worth quoting in view of the public interest now aroused on the subject: I only wish to have a word to avoid misunderstanding. I want to say that certainly catalytic action occurs also in coal hydrogenation. Yesterday the time was too short to give every detail on this complicated reaction, but I think I remarked at one point that there is catalytic action too, and we found that there are a lot of things, a lot of material, which helps catalytic action.

And he specified among the lot of things which modify the products, favorably or unfavorably, the composition of the ash, the presence of sulphur, iron oxide, alkaline compounds, compounds of the carbolic-acid group, and a German synthetic substance known as tetraline, made from naphthalene (well known as mothballs) by the addition of hydrogen.



SIR OLIVER LODGE



—*Photograph by the courtesy of Dr. Frank M. Chapman*

LOUIS AGASSIZ FUERTES

IN WHOSE DEATH, AT HIS HOME AT ITHACA, ORNITHOLOGY AND ORNITHOLOGICAL ILLUSTRATION HAS LOST A DISTINGUISHED LEADER.

SVANTE AUGUST ARRHENIUS

The death of Professor Arrhenius, which occurred at Stockholm on October 2, deprives physical science of its most remarkable leader. Arrhenius was born near Upsala in 1859, and first leaped into fame when, as a young man of twenty-five, he published his doctor's dissertation entitled, "Researches on the Conductivity of Electrolytes." This thesis contained the first guarded indication of what is known as the ionization theory, a detailed elaboration of which followed a few years later. According to the ionization theory of Arrhenius, a salt such as sodium chloride is largely broken up in aqueous solution into electrically charged ions, *e.g.*, sodium ions and chlorine ions, and this simple assumption has served as the basis for astonishing advances in our knowledge of the physical chemistry of solutions during the last forty years. Arrhenius encountered, however, most violent opposition from many quarters, and only through the enthusiastic support of Ostwald did his theory gain general acceptance. Oddly enough, while the ideas of Arrhenius were long regarded as entirely too revolutionary by many chemists, the existence of free sodium ions and free chlorine ions in the same solution being considered an impossibility even by his own professors, more recent advances have led to the conclusion that Arrhenius really did not go far enough in his assumptions, the present conception of a salt solution involving complete, rather than partial, ionization.

Through the influence of Ostwald, the young Arrhenius was awarded a traveling fellowship, under which he worked in the chief laboratories of Europe for several years, returning to Stockholm as a lecturer in the Högskola. The intense patriotism of Arrhenius held him in this position (which corresponded more closely to a professorship in a university than to its actual title) for many years, during which he refused a number of attractive offers from other countries, especially from Germany. Finally he was appointed director of the Nobel Institute for Physical Chemistry, pleasantly situated in the suburbs of Stockholm, and there he was enabled to continue free and uninterrupted research work for many years, surrounded by a small but eager band of advanced students.

Arrhenius was one of the few men who did not find it necessary to specialize; his scientific interests extended into the most diverse fields. His fame as a physical chemist, however, will probably always overshadow the researches which he carried out in biochemistry, astronomy, anthropology and cosmology. Of all recent workers, he most deserved the title of "universal scientist," not only for his broad viewpoint, but also for the warm personal contacts which his genial nature ensured him in his extensive travels. The honors conferred upon him throughout his career were innumerable. He was a Nobel prize winner, a foreign member of the Royal Society, and the recipient of practically every distinction that could be bestowed upon a scientist. In the course of several visits to America, he delivered a series of lectures at the University of California and at Yale University, and he was awarded the Willard Gibbs Medal of the Chicago Section of the American Chemical Society. The Silliman Lectures which he gave at New Haven were later published in book form under the title, "Theories of Solution." Other notable volumes from his pen include "A Text-book in Electrochemistry," "Worlds in the Making" and "Chemistry in Modern Life."

James Kendall

SVANTE AUGUST ARRHENIUS

EXCAVATIONS AT POMPEII

A MARVELOUS bronze resurrection from the deadening ashes that covered the city of Pompeii has just been officially announced by Professor A. Maiuri. Unearthing this statue in a house in the Street of Abundance is like having the dead come back to life after being buried for eighteen hundred years.

The Street of Abundance of Pompeii has been for some four or five years past the most attractive spot in that ancient Roman town which was buried under the ashes from the eruption of Vesuvius in 79 A. D. Excavations along this street have held the best pay dirt—as it were—of any of the digs in Pompeii. A huge wooden gate shuts the tourists away from this street. It is quite possible to obtain a special pass by making application to the proper authority, though no cameras are allowed. The excavation has been done slowly and carefully on a specified plan. They dug the ashes out of the street first; now they are taking the houses one at a time and cleaning them out.

The most exciting moment of this century at Pompeii came a few months ago. The excavators dug the ashes out of the doorway of the house, Street of Abundance, No. 11, and started clearing away in the *atrium*, which was the reception room. Nothing much was found. Then they dug ahead into the next room, the *tablinum*, which was a sort of office of the man of the house. At the rear of the room a pilaster, on one side of the door leading back into the second atrium, stuck up above the ashes. As they dug away the ashes, suddenly, just in front of the pilaster, a magnificent bronze head came into sight. It was the head of a young man with almost a Greek profile, with firm lips and with the most splendid head of wavy hair confined by a fillet band. The young man was looking slightly downward and to the right.

By this time all Italy was in a ferment because the news had spread that a magnificent bronze statue, and best of all an unbroken and unmutilated one, was rising from the dead past of Pompeii. Perhaps it would turn out to be an original of the best period from the atelier of a famous master!

Speculation was rife because of the position of the arms of the new bronze youth. His left arm hung easily at his side, except that the muscles of the upper arm seemed taut. The right forearm went straight out from the elbow, which was advanced a bit from the body, and the strangely closed right hand seemed to have held something. All sorts of guesses were made, but none of them was right. When the entire statue stood free, it was a nude bronze youth fifty-four inches high, standing easily with his weight on his straight right leg. Both feet were firmly planted on a circular bronze base.

In the ashes near the base of the statue were found two artistic pieces of bronze, alike except in the length of the stem pieces. From the bronze bud spread two bronze tendrils which looped gracefully away one to either side, each one curling under and over, with open flowers at the ends of the curls. On the tendrils of each bronze plant were three bronze holders.

The long stem and plant was placed in the hanging left hand of the bronze statue and the short one in his extended right hand, and lo! the transformation.

The beautiful bronze youth was a candelabrum, a "light bearer." What a magnificent and decorative way to light the tablinum of the master of this house, number 11, in the Street of Abundance!

R. V. D. MAGOFFIN